
FARMING, HUNTING,
AND FISHING
IN THE OLMEC WORLD

AMBER M. VANDERWARKER

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IN THE OLMEC WORLD

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To Mom and Dad with love and gratitude

To Greg for giving meaning to everything I do

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AGRICULTURAL RISK AND
INTENSIFICATION ALONG MEXICO'S
SOUTHERN GULF COAST:
AN INTRODUCTION

Chapter 1

Chiefdoms developed along the southern Mexican Gulf Coast during the Early, Middle, Late, and Terminal Formative periods (1400–1000 BC, 1000–400 BC, 400 BC–AD 100, and AD 100–300). Scholars interested in regional political economy for this area have long relied on archaeological data from three large sites: San Lorenzo, La Venta, and Tres Zapotes. This focus on large centers to the exclusion of smaller, outlying villages and hamlets has limited our understanding of regional political development. Scholars have also relied heavily on assumptions about regional subsistence economy, for example, that agricultural tribute was used to fund labor projects and feed the elite. Such assumptions, however, are based on little actual subsistence data. We can begin to elucidate the nature and development of Formative agriculture by shifting our attention to rural villages and hamlets and to issues of basic subsistence reconstruction.

Here I consider agricultural intensification and risk in the tropical lowlands of the Olmec hinterland during a period of political formation. To address the relationship between the development of agriculture and the emergence of complex political formations (e.g., chiefdoms and states), I consider subsistence data from two sites spanning the Formative period: La Joya and Bezuapan, located in the Sierra de los Tuxtlas approximately 100 km from the lowland Olmec centers.

The Tuxtla region is well suited for exploring this relationship. Settlement data from the region indicate that Early Formative groups were egalitarian and semi-sedentary (Arnold 2000; McCormack 2002; Santley et al. 1997). By the Middle Formative period, people had settled into more permanent villages, maintaining a relatively egalitarian social organization (Arnold 2000; McCormack 2002; Santley et al. 1997). The subsequent Late and Terminal Formative periods were marked by the emergence of a regional site hierarchy and increasing social differentiation, though the manifestation of social inequality in the Tuxtlas was not as pronounced as among lowland Olmec groups (Santley et al. 1997; Stark



PHOTOGRAPH 1.1. *The Sierra de los Tuxtlas and Lago Catemaco. (Photograph courtesy of Philip J. Arnold III.)*

and Arnold 1997a). Thus, analysis of the available subsistence data makes it possible to consider farming strategies as they developed alongside sedentism and chiefdom formation.

In order to understand an agricultural system, we need to understand the subsistence system as a whole. This requires that we answer basic questions regarding local and regional subsistence practices. What foods were people eating? To what extent did people rely on domesticated versus wild foods and how did this vary through time? Did people narrow or diversify their resource base through time? How varied were subsistence practices through time and across space? How predictable were plant and animal resources throughout the region? How did volcanic eruptions affect the distribution and predictability of these resources? Once these basic questions are answered, we can begin to address more complex questions linking subsistence to regional politics. What is the nature of the Formative subsistence system along the southern Gulf Coast of Mexico? Did Formative villagers intensify their agricultural systems? If so, what was the timing of agricultural intensification relative to political development in the region? What strategies of intensification did they choose and what were the consequences of these strategies for subsistence economy, household organization, and local and regional political development?

How did regional environmental catastrophe in the form of volcanic eruptions and ashfall affect the way Formative people made a living?

Addressing these questions requires multiple lines of evidence that are directly relevant to the reconstruction of subsistence economy. I consider archaeobotanical, zooarchaeological, and stable carbon and nitrogen isotopic data from La Joya and Bezuapan. Although these types of subsistence data are rarely considered together in the general literature, they bear directly on the research questions, as they represent the direct residues of past subsistence economies. The integration of these three kinds of subsistence data allows for a fuller understanding of Formative subsistence than would otherwise be possible.

Before I consider these data, it is important to provide the background necessary for understanding and interpreting them. Chapter 2 presents some theoretical background on the origins of agriculture. In covering this monumental topic, I focus on four major issues: the process of early plant domestication, the connection between incipient agriculture and early social complexity, the process of agricultural intensification, and strategies of risk management. Although my case study does not directly address domestication, many of the arguments put forth to explain the process of agricultural intensification have their roots in discussions of the initial process of plant domestication.

Chapter 3 presents an overview of Olmec research as it pertains to farming and political complexity. The history of the Olmec problem is particularly relevant because previous studies have set the stage for the research questions pursued here. Few subsistence studies have been conducted in the region, which has long hampered our understanding of Gulf Formative agricultural systems—this is one reason why the data presented here are so crucial. Chapter 3 also provides the environmental and archaeological background for the Tuxtlas, the region in which the study sites are located. This chapter constructs a foundation for understanding subsistence adaptations in the Tuxtlas, a foundation that is necessary for proper interpretation of the archaeological data.

The second part of the book involves the presentation and analysis of the data. These are the chapters in which I discuss specific archaeological correlates for answering the larger questions posed above. Chapters 4 and 5 consider the archaeobotanical and zooarchaeological assemblages, respectively. Both chapters consider temporal trends in these data, in addition to dealing with preservation and recovery biases, field recovery techniques, field and laboratory sampling, laboratory procedures and identification, and quantification for the subsistence data. Chapter 6 pre-

sents stable carbon and nitrogen isotopes for human, domestic dog, and white-tailed deer skeletal specimens. Indeed, it is only through the analysis of multiple kinds of subsistence data that we can begin to truly understand prehistoric systems of agriculture. Finally, in Chapter 7 I tie the analyses together and relate them to the larger research questions stated above.

AGRICULTURE AND
POLITICAL COMPLEXITY IN
THEORETICAL PERSPECTIVE

Chapter 2

The relationship between agricultural intensification and the emergence of complex political formations (e.g., chiefdoms and states) has been an enduring topic in archaeological research. Indeed, this topic continues to be prevalent in the literature, the number of theories exceeded only by the questions that remain. Though not all scholars agree about the timing of agriculture relative to the emergence of chiefdoms and states, we do know that the adoption and intensification of agriculture varied with the emergence of political complexity in different ways, at different times, and in different places. Such a complex topic cannot be adequately explained by a single theoretical framework. This is not to say that any particular case of incipient agriculture in the context of political development is irrelevant to any other. Rather, we are dealing with a set of similar processes that are structured by specific sets of historical events.

Theories linking agriculture to the emergence of chiefdoms and states have been more fully developed for arid regions, for which explanations of environmental and social circumscription are more easily invoked. Presumably, a limited resource base coupled with population increase resulted in an imbalance between people and their food supply, requiring a shift to food production. While notions of environmental and social circumscription have been criticized by some as deterministic (McGuire 1992; Orlove 1980; Paynter 1989; Trigger 1981), they have led archaeologists to collect baseline data on local and regional ecology and have provided concepts that can be measured archaeologically, such as population growth and carrying capacity (Flannery 1986; Sanders et al. 1979; Spencer 1982). Circumscription explanations have been less developed for tropical regions, where resources are more diverse and plentiful—indeed, this abundance of resources in tropical environments makes it difficult to envision an imbalance between people and food. For this reason, the notion of circumscription may be less useful for understanding the range of processes at work in tropical environments.

Determining the relationship between population growth and agricultural intensification is key to understanding the emergence of chiefdoms and states. However, before we can hope to understand this relationship, we must first explore the processes of intensification. Why did people intensify agriculture and what were the consequences of this process? Unfortunately, scholars have placed more emphasis on relating the issue of intensification to political and environmental change than to elucidating the concept of intensification itself. It is important that we infer agricultural intensification directly from archaeological data on agriculture, not from population estimates or changes in political organization. It is not until we know the organization of an agricultural system that we can understand its relationship to the larger political context. Thus, we must begin by answering the smaller questions in order to lay the foundation for answering the larger ones. What are the strategies of agricultural intensification and how do they vary relative to different environments and different crops? How do we identify these strategies archaeologically? What risks were involved in the shift to a farming economy, and how did people prevent and manage these risks? It is also important to understand that the shift from foraging to farming did not necessarily mean that people stopped collecting wild plants or hunting game. Rather, people often combined these strategies into a mixed subsistence economy (Tucker 2000; Kent 1989). Thus, when we consider agricultural intensification, we need to ask not only how and why it may have affected farming practices, but also how and why it may have affected foraging practices.

In order to address these questions, I first provide a framework for exploring issues of agricultural intensification and risk. Theories about the origins of agriculture provide a necessary starting point, since plant domestication and incipient agriculture were both well under way before the formation of complex societies, at least in Mesoamerica. Next, I consider how agriculture has been linked theoretically to the rise and maintenance of chiefdoms and states. Finally, I deal specifically with the processes of intensification in terms of strategies of land use and labor, and consider the role of risk management in farming economies.

THE ORIGINS OF PLANT DOMESTICATION AND AGRICULTURE

Some of the debate surrounding the origins of agriculture stems from the problematic use of terms (see also B. D. Smith 2001). As Blake et al. (1992) point out, we must differentiate between the origin and the spread

of agriculture. More importantly, we must be explicit in defining our terms and sticking to them. Too often “domestication” and “agriculture” have been used loosely and sometimes interchangeably—a serious problem, considering the very different processes represented by these two terms. Thus, it seems necessary to begin with some basic definitions of terms. These definitions should be considered preliminary and are intended as a point of departure for theoretical considerations of early agriculture. My aim is to avoid the confusion that has become an intrinsic aspect of this debate.

Following Price and Gebauer (1995), domestication is defined here as a biological process that involves genetic changes in plants and animals as they become increasingly dependent on human intervention for their survival and reproductive success (see also Gebauer and Price 1992). I focus specifically on plant domestication, since animal domestication is not particularly relevant to the Olmec case. Though defined as a biological process, domestication is clearly dependent on humans through activities such as seed dispersal, tending, tilling, and transplanting (Ford 1985). These activities can be subsumed under the term “cultivation,” defined here as a technological process that involves the intentional preparation, sowing, harvest, and storage of plants (Price and Gebauer 1995). Cultivation can occur on several different scales, from a small home garden to large-scale, intensive monocropping. While cultivation does not necessitate agriculture, agriculture does require cultivation.

Different from the biological process of domestication and the technological process of cultivation, agriculture is a decidedly social phenomenon.¹ Price and Gebauer (1995:6) define agriculture as

a commitment [by humans to the] relationship with plants and/or animals. It ultimately involves changes in the human use of the earth and in the structure and organization of human society—the widespread use of ceramic containers, the extensive clearing of the forest, the cultivation of hard-shelled cereals that can be stored for long periods of time, the invention and adoption of new technologies for farming and/or herding, more villages and more people, and an increased pace along the path to more complex social and political organization.

Agriculture, then, characterizes a way of life that is an outcome of the domestication process coupled with fundamental changes in social structure.

Given this broad definition of agriculture, when can a society be considered agricultural? Do people have to completely rely on domesticated foods for their survival? What about mixed subsistence strategies that

combine foraging with farming? Can extensive slash-and-burn farming be considered agriculture? Different researchers would respond very differently to these questions. Most would agree, however, that “becoming agricultural” is a process that occurs along a continuum. Because “being agricultural” means different things to different people, the practical use of this term is somewhat problematic—“Group A practices agriculture” does not tell us as much as “Group A combines extensive slash-and-burn farming with hunting game” or “Group A intensively cultivates grains using irrigation and raised-field technology for the bulk of their subsistence.” Thus, I limit my use of the term “agriculture” to broader, more abstract theoretical discussions. Whenever I refer to case studies or to my data and interpretations, I use more specific terminology (e.g., extensive/intensive, foraging/gardening/farming).

Given these working definitions, it should be clear that the process of plant domestication began long before people “became agricultural.” While scholars may disagree over the specifics of plant domestication, most would probably agree about the basic processes underlying the origins of domestication in the New World. The initial genetic manipulation of plants by humans is thought to have been accidental and unconscious, at least in the New World (Ford 1985; Galinat 1985; Pearsall 1995a; Rindos 1980; but see Layton et al. 1991; B. D. Smith 1998). For example, Galinat (1985:255) sees the process of maize domestication as an “unintentional by-product” of gathering teosinte. Teosinte would have been gathered and brought back to campsites, where it would have established itself in trash middens, places ideally suited for weedy followers. The simple tending of these plants after they had established themselves would thus have been the first step in cultivation.

Flannery (1973:307) argues that staple domesticates (seed crops) began as “third-choice foods.” These species would have required more labor in terms of harvest and preparation than gathered fruits and greens. Nevertheless, these seed crops had significant characteristics not shared by other foraged foods—they were annuals that yielded high returns, tolerated a wide range of disturbed habitats, stored easily, and were genetically malleable (Flannery 1973). Through time, these seed crops “responded with favorable genetic changes” that made them suitable as agricultural staples (Flannery 1973:307).

Rindos (1980) explains the beginnings of domestication as a coevolutionary process involving incidental dispersal and protection of plants by people. More specifically, he defines domestication as the result of predator-prey relationships characterized by mutualism in which both

humans and plants/animals benefited (see also Pearsall 1995a; Watson 1995). In the process of gathering and eating plant foods, humans acted as agents of dispersal, thereby ensuring the reproductive success of those plant species. This process led to genetic changes in the plants that made them more desirable to and dependent upon humans.

It is in the culmination of this process of domestication—i.e., the adoption of domesticates as dietary staples—that the debate lies. Generally, there are three theoretical frameworks for understanding the shift to a reliance on cultigens: coevolutionary, environmental, and sociopolitical. The coevolutionary model picks up the second part of Rindos' model. Rindos' explanation for the origins of agriculture is essentially a continuation of his explanation of the domestication process—plant/human interactions led to the abundance of domesticates, and hence the cultivation of domesticates. Eventually, a few domesticates became primary staples. This reliance on a few domesticates would have resulted in subsistence instability, which would have then necessitated intensification of those species in order to produce enough food to maintain the subsistence system. Thus, agriculture is simply the outcome of domestication.

One of the main problems with Rindos' model is that the process by which domestication leads to agriculture is simply described and left unexplained. If we consider the definition of agriculture given above, then we must ask what role people play in Rindos' model. He states that human intent, though certainly present, is unimportant for understanding the processes involved in the origins of agriculture (see also Watson 1995). "Thus, intentionality as the 'recognition of the long-term effects of behavior' must be abandoned in our study of the origins of agriculture. To deny intentionality, of course, is to deny consciousness; I am not claiming that people are incapable of reflection but only that reflection and consciousness are incapable of causing the initiation of cultural changes such as agriculture" (Rindos 1984:98). In dismissing human intention, Rindos is missing a crucial step—that human intention and reflection lead to human action, and it is human action and decision-making that lead to social change. Thus, if we choose to view agriculture as a social phenomenon involving an entire suite of changes in the way people organized their social and physical worlds, then explaining agriculture as a natural outcome of domestication is inadequate.

Winterhalder and Goland (1997:127; see also Winterhalder 1990) support Rindos' model to the extent that domestication "developed through processes of co-evolution between human beings and the resources they exploited," but they criticize the exclusion of individual

decision-makers from the process. Instead, Winterhalder and Goland propose an evolutionary ecology model that incorporates human intentionality. Specifically, they are interested in how foraging decisions about resource selection brought foragers “into contact with potential domesticates and how this might affect population density and subsistence” (Winterhalder and Goland 1997:123). To this end, they argue that explanations for the transition from foraging to farming should begin with a consideration of “immediate” variables (e.g., changes in resource abundance and prey selection) before invoking broader, systemic variables (e.g., changes in climate). In other words, we need to understand the decisions that people made with respect to domestication, and why they made them, if we are to understand the shift to agricultural production.

Winterhalder (1990) and Winterhalder and Goland (1997) explain the transition to farming in terms of changing strategies of risk avoidance. In a foraging economy, people avoid risk by pooling food between households. To deal with the unpredictability in yields for any specific foraging location (an individual can only forage in one place at a time) and because the interval between foraging episodes is relatively short (lack of long-term storage and food preservation), foragers probably pooled resources across households (Winterhalder 1990:67–69; Winterhalder and Goland 1997:140–141). In a farming economy, people may avoid risk by planting several dispersed fields. To deal with the unpredictability in harvest yields related to plot location and the possibility of crop failure, a farmer can maintain crops in several different locations at once (Winterhalder 1990:67–69; Winterhalder and Goland 1997:140–141). Thus, unlike foragers who buffer against risk at the community level, farmers can buffer against risk at the household level by combining field dispersion with grain storage. The transition from foraging to farming therefore involved a significant social shift in risk-avoidance strategies from inter- to intra-household sharing. While this model explains how the transition from foraging to farming might have occurred, it does not explain why.

Hence it is necessary to entertain other explanations for the transition to farming. The earliest models for interpreting the origins of domestication were driven by environmental variables. Childe’s (1956) Oasis Hypothesis posited climatic shifts toward drier conditions in the Levant. He argued that farming began on the plains of Mesopotamia during a dry period in which vegetation clustered around a limited set of water sources. As a result, humans and wild plants and animals congregated in these oases, which led to competition for resources. Childe (1956) thus sees the

domestication of plants and animals by humans as the solution to an environmental dilemma. Although Childe's Oasis Hypothesis was later contested by Braidwood (1960), more recent evidence indicates that Childe's original thesis was essentially correct (McCorriston and Hole 1991). McCorriston and Hole (1991:59) argue that an increase in summer aridity coupled with shrinking lakes led to seasonal shortages in critical resources. Humans adapted to these seasonal shortages by becoming sedentary, storing foods, and intensifying their exploitation of local resources (McCorriston and Hole 1991:59). The latter strategy eventually led to local depletion of wild resources, and thus people turned to plant tending as a solution to their food problems (McCorriston and Hole 1991).

Perhaps the most enduring model deals with population pressure as the causal agent in this transition (Binford 1968; Cohen 1977; Redding 1988; Watson 1995). This model is similar to Childe's Oasis Hypothesis in that it views domestication as a solution to a food shortage problem. The population pressure model explains the shift to domestication, however, not in terms of climatic change, but as a result of an imbalance between regional carrying capacity and population levels. Cohen (1977:50) defines population pressure as "an imbalance between a population, its choice of foods, and its work standards, which forces the population either to change its eating habits or to work harder (or which, if no adjustment is made, can lead to the exhaustion of certain resources)." Once population levels grew to the extent that food resources became stressed, foragers could have chosen between several different strategies. They could have chosen to do nothing, at which point people may have died from starvation, causing population levels to decline below the regional carrying capacity (Cohen 1977; Redding 1988). They could have emigrated to a new region, unless all of the neighboring regions were already inhabited (e.g., social circumscription) (Cohen 1977; Redding 1988). Or they could have turned to plant cultivation as a means of producing more food to feed to their growing population (Binford 1968; Cohen 1977; Redding 1988). This shift to a reliance on managed resources would have gradually increased until people were dependent on farming to meet the bulk of their subsistence needs.

The population pressure model differs from Rindos' coevolutionary framework by providing tangible expectations that allow us to understand some of the specifics of the origins of agriculture. Based on the model, we can expect that a reliance on farming would be preceded by an increase in population and would occur first in resource-marginal areas. Moreover, the first domesticates should be species with the potential to be staple

foods. Once people have begun cultivating domesticates, the relative contribution of these staples should gradually increase.

Agricultural origins models that rely on environmentally driven variables such as climatic change and population pressure have been criticized as being too functionalist (see Hayden 1992). As a result, some scholars have turned to social models to explain the transition from foraging to farming. Bender (1978, 1990) and Hayden (1990, 1992, 1995) see farming as a way for aspiring elites to create a surplus that can be used to fund status-related events. For Hayden, it is not resource stress and population pressure that are key issues but a breach in the ethic of resource sharing, specifically food resources.² Beginning with the assumption that people are basically self-interested, Hayden asserts that foraging groups will not produce enough food to create a surplus while an ethic of sharing is still in place. Thus, he argues that domestication likely originated first in “areas of plenty” (as opposed to marginal environments) where an ethic of food sharing would have been less developed to begin with (Hayden 1992: 12–13).

According to Hayden, domestication would have developed in the context of competitive feasting, wherein individuals hosted social events as a strategy for gaining status.³ Part of this status quest would have involved the display of exotic goods and foods. It is within this context that the first domesticated foods would have become incorporated into the diet, not as staples but as delicacies imbued with prestige (Hayden 1992, 1995). Thus, it is expected that domesticates would have been relatively minor additions to the diet for a long time. While this model is intriguing, it suffers from a lack of supporting evidence. Archaeological data from multiple regions worldwide have revealed that the first domesticates were not delicacies, as Hayden suggests, but instead were the antecedents to staple crops (B. D. Smith 1998: 209). Moreover, most of the archaeological evidence of domestication in Mesoamerica points to a protracted period of domestication and incipient cultivation prior to the emergence of chiefs (Flannery 1986; B. D. Smith 1998). Guila Naquitz, a cave site in Oaxaca, is perhaps the best example in that it provides evidence of early plant domestication that dates approximately 5,000 years before the establishment of the first agricultural villages in the region (Flannery 1986; B. D. Smith 1998).

Environmental and social models are not necessarily at odds with each other. Indeed, people may have begun farming as a result of both environmental and social causes. For example, population pressure might simply have been an additional impetus for turning feasting foods into

staple foods. Or, creating surpluses out of staple domesticates could have enabled a larger population, which in turn, would have required an intensification of agricultural production to sustain the growing population. Moreover, political competition highlighting prestige and aggrandizement may better explain one region, while risk minimization related to population increase and environmental change may better explain another. The following section further develops these issues by focusing on processes of political change—specifically, the emergence of chiefdoms and chiefly strategies of economic control, such as staple finance.

AGRICULTURE AND THE DEVELOPMENT OF POLITICAL COMPLEXITY

To understand the processes by which people adopted agriculture, we need to more fully explore the relationship between agriculture and the development of chiefdoms and states. Scholars have been dealing with this issue for decades, leaving an ever-expanding body of literature in their wake. The wealth of theory on this topic is too enormous to adequately encapsulate here. Thus, this section represents a brief overview of the main theories and has been simplified for brevity.

There appears to be a consensus that to understand the relationship between agriculture and the rise of complexity, we must consider the forms of political power available to aspiring elites—economic, militaristic, and ideological (Earle 1997; Haas 1982). While much ink has been spilt relating both militaristic and ideological power to the topic pursued here, these forms of power do not directly bear on the data analyzed in this study. Given my focus on subsistence economy, I restrict my discussion primarily to economic power. Although economic power is key to this particular discussion, all three forms of power are closely related. While economic power is necessary for funding leadership, military power is vital for enforcing leadership demands and ideological power for legitimizing them. It is the construction and maintenance of these three power bases by aspiring elites that characterizes emergent complexity and institutionalizes inequality (Earle 1997; Haas 1982).

Scholars generally classify theories of chiefdom and state formation into two broad categories: voluntaristic and coercive. Voluntaristic theories are essentially functionalist in nature. Leaders arise and are given power because they are needed to manage increasingly complex economies (Carneiro 1970; Service 1962). People thus voluntarily give up their individual sovereignty to form a larger political unit that will provide

them with economic benefits. For example, Wittfogel (1957) proposed that centralized leadership developed because it was needed to manage irrigation systems for agricultural production. This, however, raises a question: Why did centralized leadership arise in areas where irrigation systems were not needed to maintain agricultural production?

Other scholars have argued that chiefs were given power because they were needed to organize and preside over redistributive economies (Sahlins 1958, 1962; Service 1962). As outlined by Service (1962, 1975), redistributive economies would function primarily in ecologically diverse and environmentally patchy areas. These environmental parameters would lead to economic specialization, and redistribution would serve as a mechanism by which to move subsistence goods in and out of locally specialized communities (Sahlins 1962; Service 1962). By managing redistribution, chiefs would thus effectively reduce subsistence risks. In support of Service's model, Colten and Stewart (1996) have recently demonstrated that the regional exchange and redistribution of food resources was a key element in the development of social inequality among the Chumash of coastal California. However, as other scholars (Earle 1977; Peebles and Kus 1977) have also demonstrated, chiefdoms that are located in ecologically diverse areas do not necessarily require redistributive economies. Thus, while redistribution may be a component of some chiefly economies, it is not necessarily a causal factor in the evolution of *all* complex societies.

One of the main critiques of voluntaristic theories involves the assumption that people willingly give up their autonomy. However, Earle (1997:70) argues that "individuals/groups do not give up autonomy except when compelling power is exerted to make them submit." It is this idea of "compelling power" that is the focus of coercive theories (see also Carneiro 1970; Haas 1982). To compel people to submit to their demands, elites would need to gain sufficient economic control over the everyday aspects of commoner lives—specifically, the subsistence economy. If aspiring elites can gain control over the production, distribution, or consumption of subsistence resources, then non-elites become dependent on elites for their basic needs (Haas 1982; Earle 1997). Effectively, by gaining control of the subsistence economy, elites gain power over peoples' lives. Whether or not one subscribes to voluntaristic or coercive explanations as the impetus for social inequality, most would probably agree that the process by which elites gain power is key to understanding the emergence of chiefdoms and states.

Carneiro (1970, 1981) cites warfare and conquest as the prime motivators forcing compliance. He sees increasing environmental circumscription as setting the stage for warfare. In environments with unlimited agricultural land, warfare and raiding effectively dispersed villages across the landscape, keeping them relatively small and autonomous and thus maintaining relatively low regional population densities (Carneiro 1970, 1981). In environments where agricultural land was limited (e.g., narrow valleys flanked by mountains, desert, and/or water), groups became increasingly unable to disperse themselves as population levels increased. Population densities rose and eventually all the arable land was brought under cultivation. This resulted in a shift to intensive farming, whereby previously unusable land was brought under cultivation through terracing and irrigation (Boserup 1965; Carneiro 1970; Sanders et al. 1979). Eventually, a point was reached at which the only way to gain more land in this type of system was through warfare, and it was the victors who constituted the ruling class.

Sanders et al. (1979) develop this further, arguing that differential access to land and control of water were major factors in the development of class structure and political organization. It is the formation of political factions competing for control over land and water resources in circumscribed environments that led to intense conflict. At this point, however, their argument becomes largely functionalist. Rather than seeing conflict as a way for certain groups to assert their regional dominance, Sanders et al. (1979) argue that increasing conflict would have resulted in the appointment of leaders as managers of conflict resolution.

Coercive theories that depend on environmental circumscription fail to explain how political complexity could have emerged in environments where water and agricultural lands were less limited. Chagnon (1983) and Carneiro (1970) deal with this problem by invoking *social* circumscription as a causal factor for warfare, and hence the development of political complexity, in tropical environments. A village or group is socially circumscribed when its movement "is restricted by the existence of neighbors on all fronts" (Chagnon 1983:72). With the rising population densities that accompany social circumscription, villages "tend to impinge on one another more, with the result that warfare is more frequent and intense in the center than in peripheral areas" (Carneiro 1970:21). Whether a group goes to war as a result of environmental or social circumscription, Carneiro (1970:21) argues that the consequences (e.g., the development of chiefdoms and states) would be the same.

Carneiro (1970) and Sanders et al. (1979) make important points that are relevant to understanding the development of chiefdoms and states—they link the emergence of leaders and social inequality to differential access/control of agricultural lands and goods (see also Haas 1982). Other scholars highlight this connection between power and control over land and goods, as well. For example, Coe and Diehl (1980a, 1980b) argue that Olmec kin groups occupying the fertile levee lands adjacent to the Early Formative site of San Lorenzo rose to power as a direct result of the greater agricultural potential of these lands.

The focus on environmental and social circumscription as mechanisms for political development in marginal and tropical environments, respectively, returns us to the debate over whether agriculture first arose in areas of scarcity or areas of plenty. The first part of the debate seems to be a struggle between two different theoretical perspectives (process vs. agency) that are not necessarily at odds with each other. Agriculture and political complexity did not just happen—they were processes that developed out of different sets of preexisting conditions in different parts of the world that were initiated, encouraged, and manipulated by human agents in attempts at power-building and self-aggrandizement. As Flannery (1999: 18) remarks, agency and process are complementary—while change requires human agency, change also occurs within environmental and social contexts that constrain the choices that can be made.

The second part of the debate concerns the preexisting conditions themselves—whether agriculture and political complexity first developed in areas of scarcity or plenty or in the context of peace or violence. In approaching this topic, it is important that we differentiate between universal versus regional applications of these models (Blake et al. 1992). Regional models have the greatest potential to provide the necessary details to magnify and elucidate the specific processes involved in the transition to agriculture and the emergence of chiefdoms and states in a specific place at a specific time. Universal models, although lacking in detail, allow us to examine larger processes at work across time and space. The theories presented in this section, while differing in their details, all highlight important (possibly universal) points associated with the transition to agriculture and political complexity. The first point is a recognition that the environment plays a key role, whether through constraining the set of options available to people, or through providing resources that can be controlled and manipulated by aspiring elites, or as a direct catalyst (e.g., the Oasis Hypothesis). The second point deals with power and stresses the importance of understanding the role of people as active competitors

and aggrandizers who manipulate natural resources and social relationships in a quest for status and prestige (Hayden 1992, 1995). The final point deals with the physical manifestation of power, in that social inequality is actualized through the material world and is closely tied to differential access to, and control of, lands and goods by certain individuals/groups (Carneiro 1970; Earle 1997; Sanders et al. 1979). It is this process of materialization that has the greatest potential for elucidating the origins of social inequality.

If we are to focus on the common processes of differential access to and control of lands and goods by aspiring elites in the context of incipient agriculture, then we must consider the process by which elites construct and maintain their power bases. To understand more fully the economics of political formation, it is necessary to consider the sources of finance available to aspiring elites. Coined by D'Altroy and Earle (1985), staple and wealth finance are "essential to the evolution of the sociopolitical and religious institutions which provide the authority and power components of the state" (D'Altroy and Earle 1985: 187).

Generally, staple finance refers to the production of staples for local subsistence, and wealth finance to the production of wealth items for integrating the region politically. More specifically, staple finance involves payments of tribute made to the leadership by commoners. Tribute can come in different forms, including a percent of commoner food produce, produce from land worked with *corvée* labor, or some other levy specified by the leadership (Earle 1997; Hassig 1985; Steponaitis 1978, 1981). This revenue is used to support the central leadership and their personnel. Wealth finance, on the other hand, refers to the use of special objects (e.g., primitive valuables, prestige goods, exotica) that can be used to compensate lower elites and commoners for their loyalty and assistance in managing tribute mobilization (Earle 1997; Pauketat and Emerson 1991). Thus, staple and wealth finance are closely linked. Lower-level elites manage surplus extraction from commoners on a local level and funnel a percent to the regional leadership, who in return reward the local chiefs with gifts that cement and affirm their status in the eyes of their local followers.

Presumably, the mobilization of surplus requires the intensification of food production (Earle 1997). In order to produce enough food to supply the chiefs in addition to their own households, farmers have to increase production through intensification. Moreover, elites may seek to bolster their economic power by co-opting the means of intensification by building and/or maintaining agricultural facilities that make farming more productive and sustainable (Billman 1999, 2001; Earle 1997). Such facilities

might include irrigation canals or the construction of terraces on otherwise unusable tracts of land. By controlling these facilities, elites effectively control food production. On the other hand, elite power might not extend beyond the collection of tribute, leaving commoners relatively autonomous in terms of their day-to-day subsistence economies (Earle 1977; Scarry and Steponaitis 1997). Moreover, people may simply intensify food production as a means of competing with rival groups prior to the development of institutionalized leadership. In any case, the means by which a central leadership controls and amasses tribute will vary regionally, and it is this variation that is of interest.

AGRICULTURAL INTENSIFICATION AND RISK

In intensive agriculture the task is not so much to tap naturally existing sources of plant and animal nutrients, water, and sunlight as to increase their supply to support more biotic growth, to maintain the proper conditions over longer seasons and more years, and to replenish and regulate the supply of those elements that are exhausted. (Netting 1993:28)

To understand why people intensify food production, we must consider different agricultural strategies and their corollary systems of land use, labor requirements, and technological innovation. Indeed, the costs and benefits of agricultural production are key determinants of whether or not a group will choose to intensify. This section explores these issues by breaking down the monolithic concept of intensification itself. Too often scholars have invoked assumptions and interpretations of agricultural intensification without explaining the nuts and bolts of what the intensification process would have entailed. Simply stating that Group A intensified agricultural production tells us little about how Group A organized production in terms of labor and land use or buffered against risk and potential food shortage.

These are the details that are critical for understanding political change as it relates to agricultural intensification. I begin this section with a discussion of theories of intensification. While this discussion is closely related to my earlier sections on the origins of domestication and the development of agriculture and political complexity, it deals more specifically with agricultural systems. This is followed by a consideration of the forms of intensification—specifically, the strategies available to food producers to maximize agricultural yields per unit of labor—and includes a

discussion of indigenous methods of intensification in Mesoamerica. Finally, I focus on issues of agricultural risk. I discuss preventative risk versus risk response, temporal versus spatial strategies of risk reduction, and the relationship between risk and status.

Agricultural intensification is the process by which farmers seek to increase their yields by investing more time and labor per unit of land and can involve the use of new farming techniques such as irrigation canals, raised fields, or fertilizers (see below) (Netting 1993). Intensive and extensive farming can be considered separate ends of a continuum along the process of intensification. Because intensification involves an increased investment of time and labor per unit of land, then intensive cultivation focuses on fewer fields than extensive cultivation. Extensive farming, on the other hand, involves the cultivation of several fields, often dispersed throughout the countryside to take advantage of different soils and micro-environmental conditions (Stone and Downum 1999:114). Because an extensive cultivation strategy involves the cultivation of more fields, farmers have less time to devote to any one field. Moreover, because fields are often scattered, extensive cultivation requires that time be spent traveling to and from these fields.⁴ By focusing on fewer fields, an intensive cultivation strategy allows farmers to allocate time toward field maintenance and crop production and away from travel.

Risk is best defined as a known probability of loss or of falling below a minimum requirement (Cancian 1980:162, 166; Guillet 1981:7; Hegmon 1990:90; Ortiz 1980; Winterhalder 1986, 1990). Risk is different from uncertainty in that it is based on empirical knowledge. For example, good farmers understand the potential effects that drought, floods, and pests might have on their crop yields because they have some prior knowledge of these variables. Uncertainty, on the other hand, represents the true, immeasurable unknown (Cancian 1980:162, 166). For example, if a new cultigen is introduced into a region and no one is familiar with its requirements or potential yields, then the risks associated with cultivating this new crop are uncertain because the local farmers have no prior knowledge of it.

The terms and definitions presented here provide a foundation for exploring issues of agricultural intensification and risk. The best well-known treatise on agricultural intensification remains Ester Boserup's (1965) much-debated *Conditions of Agricultural Growth*. Boserup's argument is largely a population pressure model and is concerned, not with the causes of population growth, but with how population change affects agricultural systems. She examines a continuum of agricultural strategies based

TABLE 2.1. SYSTEMS OF LAND USE AS OUTLINED
BY BOSERUP (1965)

	<i>Description of Land-Use Strategies</i>	<i>Yields (Output)</i>	<i>Labor (Input)</i>	<i>Efficiency (Output/ Input)</i>
Forest fallow	Slash-and-burn, planted for 1–2 years, fallow for 20– 25 years, secondary forest succession	Greatest increase	Greatest increase	Greatest decrease
Bush fallow	Fallow for 6–10 years, true forest cannot grow back, succession of bushes and small trees			
Short fallow	Fallow for only a couple of years, succession of wild grasses only			
Annual cropping	Not a fallow system, but land uncultivated between harvests			
Multi- cropping	Most intensive system of land use, bears two or more successive crops per year	Least increase	Least increase	Least decrease

Note: The increase or decrease of yields, labor, and efficiency intensifies at each interval from forest fallow to multi-cropping.

on intensity of land use and length of fallow (see Table 2.1) and contends that shifts toward intensification require more labor investment and produce lower yields relative to labor investment than more extensive cultivation strategies. For example, shifting from a forest-fallow to a bush-fallow system involves more weeding and requires more fertilization to produce yields comparable to those of the forest fallow system. Because each step along Boserup's continuum of intensification results in less natural regrowth before burning, burning results in fewer ashes which are necessary for replenishing soil nutrients. Thus, as one moves along the intensification continuum from forest fallow toward multi-cropping, the ratio of output (crop yield) to input (labor) declines, resulting in lower overall efficiency.

Thus, increasing intensification, it is argued, results in lower efficiency and a decline in dietary standards. Given these results, Boserup (1965) suggests that farmers will only intensify agriculture if forced to do so through population pressure and/or environmental circumscription.

Some scholars have challenged the idea that Boserup's schematic for land use represents a continuum of intensification, arguing that the shift to intensification does not need to be progressive or unilinear (Guillet 1987; Vasey 1979). Vasey (1979) suggests that in the humid tropics, farmers would have skipped the short fallow "stage" altogether. Moreover, Boserup's theory does not take into account that farmers may practice different land-use systems simultaneously (Guillet 1987). Others have disputed Boserup's claims regarding labor and output, arguing that intensive agricultural strategies would have actually increased labor efficiency and led to economic progress (Bartlett 1976, 1982; Bronson 1972; Simon 1983).

In a particularly insightful article, Conelly (1992) attributes this debate over efficiency to the analysis of different temporal scales—while Boserup's theory may accurately describe long-term processes, it overlooks the benefits of intensification in the short term. Indeed, it is the short-term benefits that may explain the actual mechanism by which intensification occurs (Conelly 1992). Based on his research in the Philippines, Conelly (1992) found that labor input actually declined with the shift from long fallow to short fallow, primarily as a result of declining overall yields. Moreover, contrary to Boserup, Conelly found that small-scale irrigation was more productive and labor-efficient than short-fallow cultivation.⁵ Thus, while the transition from long to short fallow resulted in significantly lower yields, the subsequent shift to small-scale irrigation produced significantly higher yields with lower labor requirements (Conelly 1992; see also Stone and Downum 1999). "As a result, from the vantage point of farmers calculating costs and benefits *at the point of transition*, irrigation provides a clearly more efficient and attractive option" (Conelly 1992:213, emphasis in original).

Although Conelly focuses on irrigation as a measure for agricultural intensity, irrigation is only one strategy of intensification available to agriculturalists. Netting characterizes intensification as involving a suite of general strategies that can take particular forms (Netting 1993:28–29; Table 2.2). The total labor required to maintain intensive cultivation systems far exceeds that needed for extensive systems. A system of ridges and basins may trap water, but rain eventually erodes the ridges, which must then be built up again. Terracing also involves considerable labor but (like

TABLE 2.2. STRATEGIES OF INTENSIFICATION
(NETTING 1993)

<i>General Strategy</i>	<i>Tasks Involved</i>
Moving/manipulating soil to aid plant growth and prevent erosion	Tilling, ridging, terracing
Regulating water	Irrigation, drainage
Restoring/increasing soil fertility	Fertilizing with manure and household wastes, composting, mulching
Diversification of production	Intercropping by micro-environment and seasonal change
Protection of crops from pests	Weeding, fencing, guarding (garden hunting as by-product of this strategy)

raised fields) allows for the reclamation of marginal land. As illustrated above, irrigation on a small scale does not necessarily require significant labor increases relative to yields per hectare. Conelly's (1992) research demonstrates that irrigated farming was far more productive than shifting agriculture in terms of crop yields. Moreover, because irrigated farming does not require a fallow rotation, less land is needed for annual crops and thus more land can be devoted to arboriculture (Conelly 1992).

Most small-scale farming systems based on meeting basic subsistence requirements will likely become diversified during the intensification process. The notion of intensification leading to a focus on one or more staple foods is somewhat misleading. As Marcus (1982) has observed, monocropping is largely a European notion. The above example of small-scale irrigation freeing up land for tree crops highlights the potential diversification of intensive systems. Moreover, strategies of crop rotation and intercropping with nitrogen-fixing legumes (in addition to composting and mulching) can help to restore declining soil fertility, thereby maintaining intensive systems (Giller 2001; Laing et al. 1984; Lentz 2000; Netting 1993). Cultivating a garden separate from fields is yet another intensive strategy—gardens are generally permanent fixtures located close to the dwelling that are cultivated continuously and produce small yields from a great number of different foods (Matheny and Gurr 1983; Netting 1993; Ruthenberg 1976). Indeed, gardens are often the most diverse component of a farming system. This trend toward diversification can be viewed

as a risk-management strategy in that diversification combines “high production per unit area” with sustainability (Netting 1993: 32).

Locating the garden near the dwelling, in addition to convenience, allows for more constant monitoring of invading pests. Moreover, permanent fields can also be located near living quarters to facilitate crop protection. Gardens and fields are obvious targets for various pests, from insects to vermin to larger game, such as rabbits, gophers, and deer. Cultivating gardens and crop foods is almost like laying traps for animal prey (Emslie 1981; Linares 1976; Neusius 1996; Speth and Scott 1989; see also Chapter 5). Thus, while labor is expended in protecting crops against these pests, that same labor results in the capture of animal protein close to home (e.g., garden hunting), thereby reducing the time required for travel and hunting.

The specific strategies of intensification employed by prehistoric Mesoamerican farmers varied widely and include terracing, ridging, irrigation, *chinampas* (channelized raised fields, a wetland adaptation to ridging), drained fields, gardens, and arboriculture (Matheny and Gurr 1983: 87). Formative villages in Oaxaca were supported by a combination of farming systems, including dry farming, pot irrigation, small canal irrigation, and less intensive fallowing techniques (Flannery et al. 1967). *Chinampas* were used in central Mexico as early as 200 BC—this type of strategy was used extensively in gardens and is characterized by a high level of food production (Matheny and Gurr 1983; see also McClung de Tapia 2000). Irrigation-based agriculture was being practiced in the Tehuacan Valley as early as 850–150 BC (MacNeish 1971). Ethnohistoric sources from the sixteenth century indicate that the Aztecs cultivated a range of different types of gardens—orchard gardens, vegetable gardens, flower gardens, and land dedicated to avocados—which involved a complex set of tasks, such as manuring, fertilizing with mud and water, irrigating, pruning, and grafting (Matheny and Gurr 1983).

Clearly, agricultural intensification is not a homogeneous process. Intensifying food production involves a combination of strategies meant to increase yields while decreasing risk. The long-term effects of the transition from extensive to intensive agriculture may very well result in lower efficiency and a decline in dietary standards (Boserup 1965). However, as Conelly (1992) and Netting (1993) argue, the benefits of intensive agriculture in the short term—increased productivity and diversification combined with strategies of risk reduction—may be the factors that best explain this major transition in food production.

The development and intensification of agriculture bring a new set of

risks. Farmers must deal with the threat of potential shortfalls as a result of myriad factors (e.g., drought, floods, insects, environmental catastrophe, etc.). Though farmers may seek to maximize their yields through intensifying production, they also seek to minimize the risk of production failure and food shortage (Fenoaltea 1976; Schluter and Mount 1976). In some cases, farmers choose to intensify production as a form of risk minimization (e.g., the adoption of irrigation systems in drought-prone environments). In other cases, however, intensifying production may actually increase the risk of subsistence failure (e.g., extensive farming or field scattering may be the best option in environmentally patchy areas).

Understanding the choices people could have made in terms of small-scale farming strategies requires an examination of the relationship between intensification and risk. Indeed, it is just as critical to understand the ways in which farmers cope with risk as it is to understand how and why they intensify production. First, farmers must choose strategies that help both to prevent and mitigate shortfalls (Walker and Jodha 1986). Second, farmers often employ both temporal (e.g., storage) and spatial strategies (e.g., field scattering) of risk reduction (Walker and Jodha 1986). Finally, it is important to differentiate between production risks (e.g., cropping strategies) and consumption risks (e.g., food sharing/exchange).

One of the most common strategies of risk management involves the alteration of the landscape to enhance carrying capacity, such as field ridging, terracing, and the building of irrigation systems (Browman 1987). Landscape alteration serves to optimize production yields (output) as a means to minimize shortfalls. In this situation, people choose to intensify production in order to lower the risk of falling below their future subsistence requirements.

Field scattering is another cultivation strategy for buffering against risk at the production level (see Table 2.3; Bentley 1990; Browman 1987; Goland 1993; Hegmon 1990; McCloskey 1975; Scarry 1993a; Walker and Jodha 1986; Winterhalder 1990; Winterhalder and Goland 1997). Field dispersion is most commonly used in mountain regions with considerable ecological variation (Bentley 1990:55; Goland 1993; Stone and Downum 1999:114). By scattering agricultural fields throughout different micro-environmental zones and at different elevations, farmers reduce the risk of total crop loss—for example, destructive forces (e.g., insects, flash floods) may hit one field but not another (Bentley 1990:55; Browman 1987:175; McCloskey 1975:113–114; Norgaard 1989:202;

TABLE 2.3. STRATEGIES OF RISK MANAGEMENT

<i>Strategy</i>	<i>Example/Types</i>	<i>Prevention/ Response</i>	<i>Temporal/ Spatial</i>	<i>Production/ Consumption</i>
Landscape alteration (also strategy of intensification)	Field ridging	Prevention	Spatial	Production
Field scattering		Prevention	Spatial	Production
Storage	Storage of foods for times of scarcity	Prevention	Temporal	Consumption
	Storage of grains for future planting	Prevention	Temporal	Production
Diversification	Intracrop diversity	Prevention	Both	Production
	Intercrop diversity	Prevention	Spatial	Production
	Mixed subsistence strategy (includes arboriculture)	Both	Both	Both
	Diversification of general food base	Response	Spatial	Both
Sharing	Sharing of food within households	Both	Temporal	Consumption
	Sharing of food between households	Both	Spatial	Consumption
Exchange	Interzonal exchange of products	Both	Both	Consumption

Walker and Jodha 1986:19, 25). Although field dispersion entails more travel time and material transport (e.g., transport of tools and harvest yields) than field consolidation (Goland 1993:327; see also McCloskey 1972), Goland (1993) has demonstrated that families who spatially separate their fields suffer less from food shortages than those who consolidate. Thus, field scattering is an effective strategy for reducing fluctuations in annual harvests (Winterhalder 1990).

Food storage is another strategy for preventing subsistence shortfalls (Browman 1987; Fenoaltea 1976; Goland 1993; Hegmon 1990; Schluter

and Mount 1976). The storage of grains serves the dual purpose of ensuring future crop production (e.g., seeds for next season's planting) and providing a food surplus to hedge against potential future shortages (Browman 1987: 173–174; Fenoaltea 1976: 134; Goland 1993: 318; Schluter and Mount 1976: 248–249). Thus, storage functions as a risk management strategy at the level of both production and consumption. Indeed, storage is central, even necessary, to a farming economy, as farmers could not continue to farm without saving and storing a portion of the crop for future planting. For this reason, storage probably represents the single most important risk management strategy for farmers, as their future livelihood depends upon it (see also Fenoaltea 1976: 135).

Diversification is also a common strategy of risk management (Fenoaltea 1976; Guillet 1981; Walker and Jodha 1986). Defined broadly, it involves the incorporation of multiple types of foods into the diet, such that if any specific resource fails, other foods can compensate for its loss, thus avoiding overall shortfalls. Diversification can take different forms, including intracrop diversity, intercrop diversity, the use of a mixed subsistence strategy, and diversification at the level of the general food base (Guillet 1981: 10). Intracrop and intercrop diversity are cultivation strategies that avoid risk at the level of production (Clawson 1985; Goland 1993; Norgaard 1989; Schluter and Mount 1976; Walker and Jodha 1986). Intracrop diversity refers to the use of multiple varieties of the same cultigen. For example, varieties of maize have different growing requirements, mature at different times, and produce different yields (Walker and Jodha 1986: 20). Thus, if drought occurs during a particular growing season, varieties of maize that mature early might provide the only annual crop (see also Scarry 1993a). Intercrop diversity refers to the planting of different cultigens within the same plots (Guillet 1981: 11; Walker and Jodha 1986: 28–29). For example, intercropping maize with nitrogen-fixing legumes increases overall maize yields (see above). Like landscape alteration, intercropping increases yields as a means of minimizing the threat of shortfalls, thus providing another case in which agricultural intensification and risk management go hand in hand.

Employing a mixed subsistence strategy and diversifying the general food base are similar forms of diversification that overlap to some extent. While intracropping and intercropping deal specifically with cultivation strategies, a mixed subsistence strategy refers more generally to the combination of different food-producing strategies that people use. Small-scale farmers often combine cultivation with hunting, fishing, gathering wild plants, and/or arboriculture (Guillet 1981: 10). By engaging in dif-

ferent subsistence pursuits, people avoid the risk of shortages—if any single strategy fails (e.g., crop failure), people can compensate by focusing on other strategies that are spatially dispersed (Browman 1987:172–173; Guillet 1981:10; Norgaard 1989:202; Winterhalder 1990). Moreover, even if a particular strategy does not fail, the simple act of employing multiple strategies serves as a preventative (temporal) measure against food shortages in the event that a particular strategy might fail. Thus, using a mixed subsistence strategy buffers against risk at both the production and consumption levels.

Diversifying the general food base takes a mixed subsistence strategy a step further. While employing a mixed strategy diversifies the range of subsistence pursuits, diversifying the general food base deals with diversification within those pursuits. This form of diversification uses a spatial strategy to buffer against risk at both the production and consumption levels. For example, in the same way that people can diversify their cultivation strategy through intracropping and intercropping, people can also diversify their hunting and fishing strategies through increasing the range of habitats in which they procure animals, taking more types of prey, and taking more age groups (e.g., not targeting specific age/sex profiles of deer) (McCloskey 1975:118). By being less selective, people can significantly increase their hunting and fishing yields. Because of problems with long-term preservation and storage of meat in humid tropical environments prior to modern technology, diversification of animal procurement probably represented a response to immediate food shortages (as a result of failure in other food production strategies) rather than a preventative measure.

Food sharing among households and food exchange between communities also represent common forms of risk management (Browman 1987; Hegmon 1990; Norgaard 1989; Winterhalder 1986). Both strategies buffer against risk at the consumption level. Food sharing is less common in sedentary societies, but it nevertheless tends to occur when resources are either erratic or superabundant (Winterhalder 1990; Winterhalder and Goland 1997). Moreover, people tend to share foods that are not readily storable, such as meat and fish (Tucker 2000), although these resources can be dried and/or salted. Based on computer simulations, Hegmon (1990:112, 115) has demonstrated that subsistence farmers have a higher rate of survival when they practice restricted sharing, as opposed to sharing nothing or pooling everything. Each household meets its own needs first and then shares the surplus with other households (Hegmon 1990:105; see also Guillet 1981:6). In dire circumstances, however,

a household's choice to share nothing may be its only chance for survival (Hegmon 1990:112). Thus, while sharing may function as both a preventative and responsive measure to food shortages, it may not be as effective a method as diversification.

Food exchange between communities, on the other hand, may be more effective in times of food shortages than sharing at the household level. Because different communities are spatially separated, production problems leading to food shortages might affect one community and not another (Goland 1993). Flash floods, for example, tend to be rather localized. Thus, when a community is faced with shortfalls, its members may have to rely on intercommunity kin networks to see them through difficult times. Moreover, in regions that are characterized by ecological variation, individual communities might specialize in different subsistence pursuits (e.g., coastal fishing communities) and rely on food exchange to round out their diets (see also Norgaard 1989:211). In this situation, community members facing food shortage can either relocate to another community in which resources are more abundant or negotiate delayed reciprocal food exchanges with (kin) groups in other communities. In terms of the risk management strategies discussed thus far, intercommunity food exchange was probably a last resort failing other options for preventing and coping with food shortages.

Given my focus on the intersection between food production and political complexity, it is important to consider the relationship between risk and social status, or more specifically, how social status conditions risk management. Both Cancian (1980) and Hegmon (1990) argue that people respond differently to risk based on their socioeconomic position in society. Hegmon (1990:91) argues that rich peasant farmers are able to try more highly variable farming methods. Under conditions of risk, rich farmers have more resources, and thus can afford the costs and survive the fluctuations. Poor farmers, on the other hand, do not have the resources to buffer against fluctuations, and thus tend to rely on more traditional techniques (Guillet 1981:4). It is only under conditions of *uncertainty* that poor farmers will adopt new techniques (Cancian 1980:173; Hegmon 1990:91). Once operating under uncertainty, poor farmers have already exhausted all of their options for coping with existing shortfalls—thus, they are more apt to take chances and try new techniques that have unpredictable outcomes.

How does this relate to status differences in prehistoric chiefdoms and states with farming economies? Did elites and commoners share

equally in the risk of production failure and food shortfalls? Probably not. Fenoaltea (1976: 132) argues that the risk of “time running out” at critical junctures in the agricultural calendar is largely the problem of commoners, because the chief/lord would have had the power to “exercise his prior claim to labor.” Thus, commoners would have been unable to “shift the risk of hunger” to the chief, and instead would have had to rely on the chief to be altruistic enough to cut demands for goods and/or labor (Fenoaltea 1976: 133; see also McCloskey 1975: 117; Johnson et al. 1982: 187). On the other hand, unless faced with social and/or environmental circumscription, commoners could have always dispersed into the countryside or abandoned their chiefs in times of food scarcity. Nevertheless, elite demands on goods and services may have added an additional risk with which small-scale farmers would have had to deal. Given this uneven power structure, commoners likely employed a combination of risk management strategies to both prevent and deal with shortfalls. Moreover, we might even expect that the number and types of risk management strategies used by commoners would have increased with the formation of hierarchical political institutions.

SUMMARY

This chapter has dealt with a variety of issues regarding the origins and maintenance of agricultural systems and the emergence of hierarchical political institutions. The first section considered the domestication process as it relates to evolutionary, ecological, and social models. The discussion of these models of domestication emphasized the importance of both agency and process for understanding this significant transition. The second section related the origins of food production to the emergence of political complexity. The enduring questions remain: Why did people give up their autonomy, and how was food production linked to this process? I explored both voluntaristic and coercive theories, focusing on the connection between economy and the idea of compelling power. To understand the connection between the adoption of food production and the emergence of complexity, we need to recognize that we are dealing not with a single explanation but instead with similar sets of processes that are historically contingent.

The relationship between agriculture and political complexity forms a critical axis of social transformation. To begin to understand the nature of this relationship, we must consider not only its initial formation but

also its subsequent development. It is for this reason that issues of intensification and risk are so critical. Why did people intensify food production and what are the consequences of this process? How did the development of social inequality and hierarchical political institutions affect the ways in which people managed the risks of food production? An adequate examination of these issues requires a consideration of both short- and long-term processes. In the following chapter, I provide the details necessary for examining these processes during the Formative period along the southern Gulf Coast of Mexico.

POLITICS AND FARMING IN THE OLMEC WORLD

Chapter 3

The Formative period (1400 BC–AD 300) marked the development of political complexity and the adoption of a mixed farming economy along the southern Mexican Gulf Coast (Figure 3.1). Large civic-ceremonial centers were established at San Lorenzo, La Venta, and Tres Zapotes during the Early, Middle, and Late Formative periods, respectively (Figure 3.2). These large political centers served as seats of power for regional elites who oversaw large labor projects like extensive earthen and stone monument construction.

The nature of Olmec political organization has long been a subject of contention in Mesoamerican archaeology. Traditionally, the debate has centered on the scale of political complexity—particularly, whether the Olmec constituted a chiefdom or a state (Bove 1978; Demarest 1989; Diehl 1989; Drucker 1981; Earle 1976; Grove 1981, 1997). Recently, the focus has shifted toward identifying and understanding regional variation in socioeconomic organization (McCormack 2002; Pool 1997; Santley 1992; Stark and Arnold 1997a, 1997b). Continuing excavations at San Lorenzo, La Venta, and Tres Zapotes, as well as regional surveys and excavations in the Sierra de los Tuxtlas, have begun to show the range of regional variation in terms of settlement hierarchy and social organization (Arnold et al. 1992; Cyphers 1996a, 1996b; González 1989; Pool 1997, 2000; Santley 1992; Santley et al. 1997). In focusing on the Tuxtlas and other areas outlying the large centers, recent archaeological research has begun to work out some of the details needed to better understand the nature and timing of early farming vis-à-vis the emergence of chiefdoms throughout the region.

This chapter examines the relationship between early agriculture and developing political complexity along the Gulf Coast. Because of regional differences in archaeological patterning between the Sierra de los Tuxtlas and the lowlands southeast of the Tuxtlas, I consider these Formative manifestations separately. I focus first on the lowlands and deal with issues of regional variation in cropping strategies and growth potential, archae-



FIGURE 3.1. *General regions of Mesoamerica.*

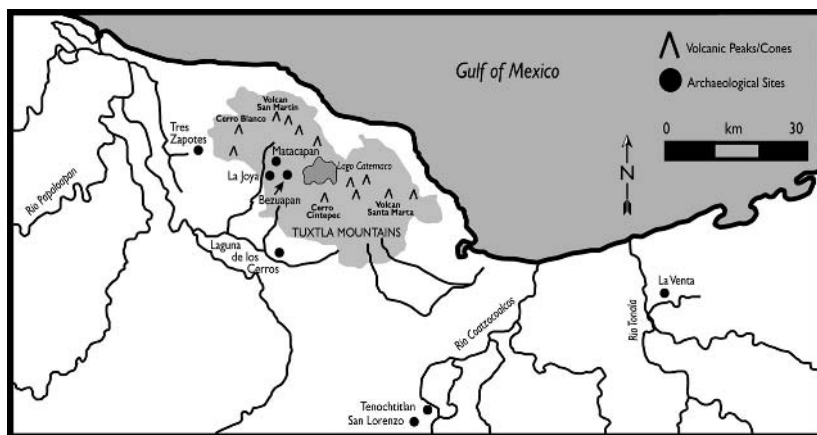


FIGURE 3.2. *Selected Formative sites along the southern Gulf Coast of Mexico.*

ological evidence of Formative subsistence economy, and the relationship between political power and economic control. This is followed by a consideration of the same issues in the Tuxtla Mountains. Because the Tuxtlas are the focus of my analysis, I include a detailed description of the local ecology to help provide a context for understanding the plant and animal data. Moreover, because this region is volcanically active, I also consider how volcanic eruptions and ashfall might have affected local

ecology in terms of the availability of wild flora and fauna and the potential for farming. The final section of this chapter presents the archaeological sites that form the basis for my analysis—La Joya and Bezuapan. I provide details about excavations, site location relative to local topography, and periods of Formative occupation.

THE LOWLAND OLMEC

The Gulf lowland Olmec flourished during the Early and Middle Formative periods (1400–1000 BC and 1000–400 BC) at the sites of San Lorenzo and La Venta, respectively. Both sites witnessed extensive mound-building and monument construction, symbols of the power wielded by regional leaders. Although the transition to the Late Formative period (400 BC–AD 100) has been characterized as the collapse of Olmec society (Bernal 1969; Diehl 1989; Diehl and Coe 1995), it was during this time that Tres Zapotes was established as a regional center. Current models of Olmec political economy posit a settlement hierarchy with a minimum of three tiers; the first tier consists of the major centers yielding extensive monumental architecture (e.g., San Lorenzo, La Venta, and Laguna de los Cerros), the next tier of secondary centers with fewer monuments, and the final tier of villages and hamlets lacking monumental construction (Drucker 1981; Grove 1997; Grove et al. 1993; Rust and Sharer 1988). Presumably, the large centers would have commanded tribute from the lower tiers in the form of food (e.g., maize) and labor for monument transport (e.g., colossal heads and stelae) and architectural constructions (Bernal 1971; Coe 1965; Heizer 1960, 1962, 1971).

Assessing the validity of such tribute-based models is difficult. Most archaeological research has focused on the large sites, and as a result, we know very little about those sites composing the lower portions of the proposed settlement hierarchy. Most regional studies that have related political complexity to agriculture have explored this relationship using indirect methods such as carrying capacity calculations, ecological and settlement studies, analogy to modern farming practices, and changes in ground stone technology (Borstein 2001; Coe 1981; Coe and Diehl 1980a, 1980b; Drucker and Heizer 1960; Grove 1981; McCormack 2002). This focus on indirect methods for assessing the past subsistence economy is a product of a lack of available subsistence data. Preservation of organic remains in tropical environments like that of the Gulf Coast is relatively poor. Moreover, there are too few archaeobotanists and zooarchaeologists conducting research in the region. Thus, there have been

few analyses of plant and animal data, and the analyses that have been conducted are not adequately reported. So although most regional studies have modeled the relationship between farming and political complexity in the absence of direct subsistence evidence, they have nevertheless been critical for exploring the possibilities of this relationship. The next step, however, must involve testing these possibilities with actual subsistence data.

Farming Strategies in the Lowlands

Although some have questioned the potential of tropical farming (Bernal 1971; Meggars 1996; Sanders 1971), more recent ecological and archaeological studies have shown that farming can be quite productive in tropical environments along the Gulf Coast of Mexico (Killion 1987, 1990, 1992; Pope et al. 2001; see also Grove 1981). High year-round temperatures and precipitation allow for two annual crops in the lowlands—a wet season or *temporal* crop and a dry season or *tapachol* crop (Bernal 1971; Coe 1974, 1981; Drucker and Heizer 1960). The wet season spans June through November, and the dry season from February to May, with some regional and temporal variability (Coe and Diehl 1980b). Dry season crops are somewhat riskier because of the potential for drought and the increased threat of pests (Drucker and Heizer 1960). Even riskier are two secondary crops, the *chamil*, which is planted in March, and the *tonamil*, which is planted in August/September (Coe 1981). Thus, there is the possibility for four annual maize crops, but the wet and dry season crops are the most prevalent.¹

Olmec farmers in the Gulf lowlands could have used two different but complementary strategies—river levee farming and upland farming. Soils in the lowlands vary, with the most fertile land, or *tierra de primera*, located along the river levees (Coe 1974, 1981). These lands are flooded annually during the wet season and thus can only be cropped once per year (during the dry season) (Coe 1974, 1981; Coe and Diehl 1980a, 1980b; Grove 1981). Nevertheless, crops grown on levee lands produce the highest maize yields in the region, because flood-deposited alluvium renews the soil fertility (Coe 1974, 1981; Coe and Diehl 1980b). Moreover, levee lands do not require a period of fallow and require less annual clearing, because there is little time for the regeneration of secondary growth (Coe and Diehl 1980a). Upland soils are less fertile than river levee soils, but both a wet season and dry season crop can be grown here

(Coe and Diehl 1980a). In modern times, three to four crops are grown in succession (about 2 years of cropping), followed by a fallow period of 3–5 years (Coe and Diehl 1980a; Drucker and Heizer 1960). Thus, Olmec farmers would most likely have practiced a forest-fallow or bush-fallow shifting cultivation strategy in the uplands (Coe 1974; see also Chapter 2).

Formative Subsistence Economy in the Lowlands

Olmec subsistence economy has generally been characterized as a mixed strategy of farming, fishing, and turtle-collecting, with only a minimal focus on the hunting of terrestrial animals (Bernal 1971; Coe 1974; Coe and Diehl 1980a; Rust and Leyden 1994). A combined focus on farming and aquatic resource exploitation would not be surprising, given that the best farmland is located along the rivers (Rust and Leyden 1994). When the rivers rise during the wet season, they transform the savannas into large lakes. As the rains stop and the rivers begin to recede, fish become trapped in oxbow ponds or lakes and are easily caught (Coe 1981). Indeed, the juxtaposition of the productive *tierra de primera* and the easily exploitable aquatic resources make this riverine ecozone a highly productive and minimally risky setting in which to make a living (Grove 1981; McCormack 2002).

Direct archaeological evidence of Formative Olmec subsistence in the lowlands includes pollen, phytolith, macrobotanical, and faunal data from San Lorenzo, La Venta, and San Andrés (located approximately 5 km northeast of La Venta). Phytolith analysis from San Lorenzo suggests maize cultivation was under way by the Early Formative period (Zurita-Noguera 1997). The presence of maize, beans,² and squash macrobotanical remains has also been documented at Early Formative San Lorenzo, but these analyses have yet to be published (see Cyphers 1996b). Analysis of zooarchaeological materials conducted by Elizabeth Wing (1980, 1981) remains the only reported and accessible Formative study of vertebrate faunal remains in the region. This assemblage was excavated by Coe and Diehl in the late 1960s (see Coe and Diehl 1980a, 1980b) during their Río Chiquito Project centered at the site of San Lorenzo. Analysis revealed that aquatic resources figured more prominently in the San Lorenzo diet than terrestrial animals, with freshwater species somewhat less important than estuarine, brackish, and marine species (Coe and Diehl 1980a; Wing 1980). Although fishing and turtle collecting were the most

common methods of faunal procurement, domestic dogs were also important dietary staples (Wing 1980, 1981). Coe and Diehl (1980a:389) speculate that dogs may have been fed a special diet of maize to prepare them as a food source.

Pollen and macrobotanical evidence from La Venta reveal that maize was cultivated there as early as 2250 BC (Rust and Leyden 1994). Rust and Leyden (1994:181) document an increase in both the size of *Zea* pollen grains and the presence of macrobotanical maize remains through time at the site. Moreover, a sharp decline in the frequency of pollen from mangrove-related plants, paralleled by an increase in pollen indicative of forest clearance (Graminae and Cyperaceae), suggests the clearing of mangrove-filled levees for farming purposes during the Early Formative period (Rust and Leyden 1994). Maize use increased throughout this period, and the morphology of maize kernels became significantly less diverse, resulting in a dominant variety of popcorn³ by the end of the Early Formative (Rust and Leyden 1994). Rust and Leyden (1994) argue that maize cultivation at La Venta became more important during the Middle Formative period, paralleling increases in settlement and ceremonial activity at the site. They also mention the importance of beans and palm nuts in the La Venta subsistence economy (Rust and Leyden 1994:182). However, only the maize remains are quantified, making it impossible to evaluate the importance of maize relative to the other plants in the La Venta diet, or to assess whether or not beans were fully domesticated at this time.

More recent pollen evidence from San Andrés in western Tabasco, however, has pushed back the date of domesticated maize cultivation to 4800 BC (Pope et al. 2001). The initial appearance of *Zea* pollen appears at 5100 BC and corresponds with evidence of extensive forest clearing in the form of disturbance pollen. Morphological changes in *Zea* pollen grains suggest that people transformed wild teosinte into domesticated maize within a 200-year period (Pope et al. 2001). In addition, direct AMS dating by Pope et al. (2001) of *Phaseolus* seeds from San Andrés indicate that beans had become part of the diet by the end of the Middle Formative period (399 BC).

In terms of animal resources, Rust and Sharer (1988) and Rust and Leyden (1994) stress the importance of aquatic vertebrates—specifically, fish and turtles—in the diet of La Venta residents. Moreover, they suggest a status-related pattern in the consumption of larger terrestrial vertebrates like deer and dog. Apparently, significantly more large mammal remains were identified at mound sites than at non-mound sites in the La

Venta settlement area. This pattern is interpreted to represent a positive correlation between status and the consumption of larger mammalian taxa. While this pattern is intriguing, neither Rust and Sharer (1988) nor Rust and Leyden (1994) report the faunal data in raw or summarized form, making it difficult to evaluate their arguments.

Changes in ground stone technology at lowland Olmec sites also point to the increased production and consumption of maize through time. Moreover, it appears that the productivity of maize increased substantially during the second millennium BC throughout Mesoamerica. Based on data from Oaxaca, Kirkby (1973) argues that 1700–1500 BC was a critical time in the evolution and domestication of maize, in that it had become productive enough to warrant extensive forest clearing for its cultivation. Macrobotanical data from the Olmec heartland, however, place this critical domestication/productive threshold for maize about 500 years later, circa 1000 BC (see above; Rust and Leyden 1994; see also Borstein 2001). The hard-kernel popcorn variety of maize identified at La Venta would have offered better yields and storability than earlier varieties, but would have required more intensive processing and grinding (Grove 1981; Rust and Leyden 1994; B. D. Smith 2001). Thus, we can expect that changes in maize production would be reflected in changes in ground stone use. Grove (1981: 389) cites a dramatic increase in grinding implements across Mesoamerica during the Early Formative period. Moreover, basalt manos and metates are ubiquitous at Formative period San Lorenzo (Coe and Diehl 1980a, 1980b). At present there is little reported concerning changes in the frequency or intensity of use of these maize-grinding tools, but Coe and Diehl (1980b: 139) do mention an increase in the long-distance exchange of basalt during the Early Formative. At La Venta, an increase in basalt grinding implements through time correlates with the increase in maize density ratios (Rust and Leyden 1994: 181).

Changing Settlement in the Lowlands

Settlement patterns also offer clues to changes in farming practices through time. Based on recent large-scale surveys around San Lorenzo and Laguna de los Cerros in the Coatzacoalcos and San Juan drainages, respectively, Borstein (2001) has identified a settlement shift away from lowland, riverine settings and toward upland settings around 1000 BC, well after the emergence of chiefdom-level political complexity in the region. This shift in settlement reflects a major change in subsistence

strategies from river levee farming and the exploitation of aquatic fauna toward swidden farming. This move to the uplands in part signifies a greater commitment to farming—Early Formative people chose to limit their exploitation of the highly predictable, low-risk aquatic resources offered by lowland riverine settings in order to farm year-round in the uplands. Thus, it appears that people began to intensify agriculture about 200 years after the elevation of San Lorenzo as a regional political center.

Based on high maize and fish yields in the region and given Formative population levels, Borstein (2001) rules out population pressure as an impetus for this move into the uplands (see also Coe and Diehl 1980b:139). Rather, it appears that this settlement shift may be connected to a rise in regional warfare. Borstein (2001) interprets the increased depiction of weapons on monuments at San Lorenzo as an indicator of increasing warfare. People may have fled the lowland polities because of this threat of conflict. Alternatively, this settlement shift toward the uplands may reflect increasing political factionalism, with upland polities competing with and usurping followers from lowland polities such as San Lorenzo. An increase in monument recycling at San Lorenzo points to the inability of San Lorenzo elites to maintain access to the basalt coming out of the Tuxtla Mountains (Borstein 2001). It is possible that elites from Laguna de los Cerros may have been responsible for cutting off the flow of basalt into the lowlands (Borstein 2001). By controlling regional basalt trade, elites at Laguna de los Cerros would have been in an excellent position to strengthen their following.

Farming and Politics in the Lowlands

Most of the explanations for social organization and the emergence of political complexity in the Olmec lowlands hinge on economic control of prime levee lands, trade in basic subsistence tools, and maize surplus and tribute (Coe 1981; Coe and Diehl 1980a, 1980b; Heizer 1960, 1962; Rust and Leyden 1994). Coe and Diehl (1980a, 1980b) have argued that kin groups occupying the levee lands around San Lorenzo rose to power as a direct result of the greater agricultural potential of these lands. Because river levees offered higher maize yields, these lands probably achieved renown as prime maize-producing areas (Coe and Diehl 1980b:148). Kin groups working these lands would have been able to generate and store more surplus maize than other farming groups in the region, which may have translated into the increased ability to underwrite feasts and other public events (Coe and Diehl 1980a; 1980b). In other words, the increas-

ing disparity in maize production between groups occupying levee lands and groups not occupying levee lands would have led to increasing social inequality among these groups, with the former achieving political eminence (see also Chapter 2).

Borstein's settlement data, however, suggest that people were less focused on agriculture prior to 1000 BC than they were on the exploitation of aquatic resources (Borstein 2001). He argues that aquatic foods, not maize, underwrote the rise to power of Olmec elites (Borstein 2001)—the exploitation of which still would have made land along river levees important to this process. I suggest that levee lands were important both for farming maize and for access to easily exploitable aquatic resources—it was likely the combination of both factors that made levee lands so desirable in the first place. Based on the size, frequency, and potential productivity of maize remains from La Venta (Rust and Leyden 1994), it seems unlikely that maize surpluses alone could have funded the Early Formative Olmec rise to power.

The control of levee lands may also have been key to the monopolization of long-distance trade routes by aspiring Olmec elites. Coe and Diehl (1980b:147) suggest that San Lorenzo elites may have controlled the distribution of scarce resources like basalt and obsidian that had to be obtained through trade. Because basalt is the raw material for maize-grinding tools, the implication is that aspiring elites would have controlled the means of subsistence production—or at least the means of maize processing. Indeed, it may have been the usurpation of basalt trade routes by elites at Laguna de los Cerros that cost San Lorenzo many of its followers (Borstein 2001).

In addition to understanding the control of key resources by aspiring elites, we also need to consider how these resources may have been deployed. Clearly, funding was necessary to support large labor projects like mound building and monument carving (see also Heizer 1960, 1962). At present, we can only speculate about the nature of tribute collection and mobilization. If domesticates (or aquatic resources) were necessary for funding large labor projects at political centers like San Lorenzo and La Venta, then who was supplying these goods? Initially, these projects may have been funded by aspiring elites—if kin groups occupying the river levees rose to power because of better access to aquatic resources and prime farmland, then it would have been these aspiring elites who were generating the surpluses necessary to fund their mound-building projects.

How would a system in which aspiring elites generated food surpluses to sponsor public events be transformed into a system whereby common-

ers produced and supplied food surpluses to elites? By repeatedly sponsoring public events with their own surpluses, individuals create bonds of indebtedness between themselves and their guests (Kirch 1991; Knight 1986). When guests are unable to reciprocate, perhaps because they cannot amass the resources to which aspiring elites have access, they become locked into a cycle of debt (Clark and Blake 1994). Once this cycle begins, certain individuals will continue to be privileged over others when it comes to amassing resources and hosting large events. Thus, by hosting and funding feasts and other public events, aspiring Olmec elites could have effectively transformed the social landscape into an unbalanced patron-client network, thus planting the seeds for social inequality. This process may have culminated in the mobilization of subsistence goods from commoners to elites, whereby tribute payments constituted a means of repaying debt. A thorough evaluation of regional tribute mobilization, however, awaits the collection and analysis of more data from multiple sites at different scales of the regional settlement hierarchy.

Clearly, archaeological evidence of subsistence is key to understanding the basic underpinnings of an Olmec political economy. It is unfortunate that we know so little about food during the Formative period. There are many assumptions about subsistence economy in the Olmec literature, but few have been grounded in actual subsistence data (but see Rust and Leyden 1994; Rust and Sharer 1988). Careful collection and analyses of subsistence data need to be conducted to address the development of agriculture in the region, the rate of agricultural intensification, and the uses of surplus crops in support of political projects and competitive feasting. Fortunately, recent research, including the work presented here, is increasingly focusing on domestic contexts and activities that necessarily include food.

THE SIERRA DE LOS TUXTLAS

The Sierra de los Tuxtlas provides an excellent location for examining the development of agriculture and the emergence of political complexity during the Formative period. Recent surveys and excavations in this region have revealed extensive Formative occupations that are contemporaneous with the large political centers in the lowlands (Arnold et al. 1992; Pool 1997; Santley 1992; Santley et al. 1997). Formative peoples living in the Tuxtlas were undoubtedly aware of their Olmec neighbors to the southeast—indeed, they even shared similar ceramic styles (McCormack 2002; Santley and Arnold 1996). Political developments in the Tuxtlas,

however, appear to have been independent of those in the lowlands (McCormack 2002; Santley and Arnold 1996). Regional surveys have shown that the settlement system in the Tuxtlas was not as hierarchical as lowland settlement (Santley et al. 1997; see also Stark and Arnold 1997a). A settlement hierarchy was not even present in the Tuxtlas until the Late Formative period, well after the collapse of the large Olmec centers of San Lorenzo and La Venta. Indeed, the concentration of wealth items encountered at sites like San Lorenzo and La Venta is absent from the Tuxtlas (McCormack 2002). A consideration of Formative developments in the Tuxtlas with respect to the neighboring lowlands allows us to examine regional variation in terms of the relationship between the development of a farming economy and the emergence of political complexity.

Farming Strategies in the Tuxtlas

The Sierra de los Tuxtlas is a mountain system that is primarily volcanic in origin, created as the Cocos plate subducted and melted under the North American plate. The Tuxtla mountain range trends northwest to southeast, measuring approximately 90 by 50 km (Andrle 1964). This region has been an active volcanic area since at least the Oligocene and is characterized by two distinct ranges separated by Lago Catemaco (Andrle 1964; Byrne and Horne 1989). There are four large volcanoes in the region, in addition to lower peaks, volcanic cones, and foothill ridges (Andrle 1964). The tallest volcanic cones reach as high as 1,660 m (Andrle 1964; Gómez-Pompa 1973). Most of the region, however, falls below 1,000 m. Soils in this region consist mostly of volcanically derived yellow and brown Andisols, which are extremely rich in nutrients like feldspars, iron oxide, magnesium, potassium, and aluminum (Andrle 1964). Andisols are able to support permanent agriculture with two to three crops per year (Andrle 1964; Gómez-Pompa 1973).

Classified as a humid tropical region, the Tuxtlas are characterized by frost-free conditions, high temperatures throughout the year, and a relatively short dry season (Andrle 1964; Gómez-Pompa 1973; West 1965). Annual weather trends include northeast trade winds, occasional easterly waves, and *nortes* brought by North American polar air masses (Andrle 1964). Mean annual temperatures range from 22°C–26°C (Andrle 1964; Gómez-Pompa 1973). January and February are the coolest months, and May and June are the warmest (Andrle 1964). Although some freezing has occurred at the higher levels of Volcán San Martín Tuxtla, it is generally not frequent or protracted (Andrle 1964).⁴ As a result of the hot climatic

conditions, the area is composed of natural vegetation that is intolerant of frost (Gómez-Pompa 1973; West 1965).

The rainy season begins in June and lasts through November, although some rainfall continues in January, February, and March (Andrle 1964). The dry season spans February to May (Andrle 1964). Annual mean precipitation averages over 2,000 mm, and ranges from 1,800 mm in the southern portion of the region to 4,000 mm in the northeastern portion. The northern (or windward) side of the Sierra de los Tuxtlas is characterized by summer rains with monsoon influences (Gómez-Pompa 1973). While the southern (or leeward) side of the Tuxtlas also experiences heavy summer rains, precipitation on this portion of the Tuxtlas is less dramatic. This pattern of differential rainfall continues into the winter months, when rainfall and low temperatures are brought by polar air masses (*nortes*)—on the northern side, 10%–18% of the annual rainfall occurs during the winter season, while less than 5% of the annual rainfall occurs in the winter on the southern side (Gómez-Pompa 1973). Another form of precipitation common to (and also restricted to) the Sierra de los Tuxtlas is fog found in cloud forest, which occurs on the highest mountain slopes anywhere from 40–100 days per year (Andrle 1964).

Overall, the Sierra de los Tuxtlas is an ecologically diverse region replete with an abundance of faunal and floral resources. Moreover, the combination of regional climatic variables such as high temperatures, frequent rainfall, and year-round frost-free conditions, coupled with rich volcanically derived soils, makes the Tuxtlas an excellent place for farming. There are, however, major differences in local ecology between the Tuxtlas and the Olmec heartland that would have undoubtedly affected farming strategies.

The Sierra de los Tuxtlas has been a volcanically active region for millennia, with several eruptions occurring during the Formative period from vents near Cerro Mono Blanco. The first eruption occurred near the close of the Early Formative (1250–900 BC), the second toward the end of the Late Formative (150 BC), and the third during the Terminal Formative (AD 150–250) (Santley et al. 1997). Volcanic eruptions and subsequent ashfalls would have impacted local climate, ecology, agriculture, and human health and livelihood. The accumulation of ash in the sky reduces the amount of solar radiation that can penetrate the lower atmosphere (Gill 2000: 199). As a result, changes in atmospheric factors such as air pressure, temperature, precipitation, and cloudiness create localized warmings and coolings (Gill 2000: 200). Evidence from colonial documents throughout Mesoamerica indicates a connection between major

eruptions and the incidence of drought and subsequent famine (Gill 2000:235–236). The implication is that changes in local climate resulting from eruptions lead to episodes of drought. It is probably a combination of factors in addition to drought, however, that accounts for the widespread famine that accompanies volcanic eruptions.

Eruptions and ashfall destroy natural vegetation, agricultural lands, crops, buildings, and in some cases human and animal life. Based on a study of the 1943 eruption of El Parícutín in central Mexico, Eggler (1948:426–427) observed that few trees were burned from exposure to lava flows—because flows move slowly, the basaltic rock at the front and base of the flow had time to cool. Eggler (1948:427) found that it was not the lava but the volcanic ash that most negatively impacted vegetation. The deposition of volcanic ash on vegetation can reduce the amount of oxygen that plants absorb into their root systems, in addition to causing mechanical breakage from the weight of the ash (Eggler 1948:427). The survival of vegetation was thus highly correlated with the depth of ashfall. With the exception of pine and oak trees, few plants survived ashfalls over 30 inches (76.2 cm) in depth (Eggler 1948:429). Some shrubs and herbs survived up to 30 inches (76.2 cm), but a greater diversity survived when covered by less than 20 inches (50.8 cm) of ash (Eggler 1948:429; see also Chase 1981:64).

Volcanic ash can also be dangerous to humans and animals—heavy ashfall can result in death, and light to moderate ashfall can irritate eyes and respiratory systems (Chase 1981:63). Moreover, gases released from both the eruption and the volcanic ash combine with atmospheric water, resulting in acid rains, which are obviously detrimental to humans, other animals, and plants (Chase 1981:63; Warrick 1975:11–12). Acid rains also contaminate water sources and thus reduce the abundance of aquatic resources (Chase 1981:64). The weight of the ash on buildings can collapse roofs, especially during the rainy season—Chase (1981:64) calculates that 1 inch (2.5 cm) of ash on a roof adds 10 pounds of weight per square foot (14.7 kg per m²). If ashfall occurs during the rainy season, it can also lead to flooding, erosion, mudflows, and landslides (Chase 1981:64).

Regional recovery from such a major environmental disaster would be a slow process. It would take approximately 30–40 years after ashfall, or 1–2 generations, for soils to weather sufficiently to support climax vegetation (Chase 1981:64). While larger trees might survive and continue to fruit, most plant life would require time to regenerate (Eggler 1948:427). The potential for local terrestrial fauna to rebound is directly dependent

on the succession of plant life. We can also expect that smaller mammals with shorter reproductive cycles (e.g., rabbits) would rebound more quickly than larger mammals with longer reproductive cycles (e.g., deer). Aquatic resources, on the other hand, tend to rebound more quickly than terrestrial plants and animals (Chase 1981:64). Thus, in the short term, people would have had to adjust their subsistence strategies in order to survive. In terms of plant foods, this may have meant a reduction in farming and gardening and an increase in the collection of large tree fruits. In terms of animal resources, this may have meant a reduction in large game and an increase in the exploitation of small mammals and aquatic resources. Overall, we can expect that people would have diversified their subsistence strategies (see Morton and Shimabukuro 1974) and expanded their collecting and hunting ranges to extend beyond the area of volcanic impact. In the long term, however, volcanic eruption and ashfall have a positive impact on agricultural production, in that volcanic ash significantly contributes to soil fertility (Giller 2001). Thus, once soils had weathered sufficiently for plant life to regenerate, we would expect that Formative people would have gradually shifted back toward farming.

In addition to active volcanism, the Tuxtlas also differ from the lowlands in terms of the location of good farmland vis-à-vis aquatic resources. In the lowlands, the best lands are the river levees that are located adjacent to large river channels. In the Tuxtlas, however, the best lands are not located adjacent to large bodies of water. While many Formative Tuxtla sites are located near the Río Catemaco, this river is significantly smaller and faster than the Coatzacoalcos, lacking the adjacent levee lands that are characteristic of the lowlands. Moreover, as McCormack (2002:291) has noted, “[T]he slopes of the mountains and cinder cones surrounding lakes in the Sierra de los Tuxtlas make the prospects of farming adjacent to these water sources difficult.” Indeed, many lakes and small bodies of water are surrounded by steep slopes (McCormack 2002). Thus, while farming and fishing were easily coordinated in the lowlands, coordinating these subsistence activities in the Tuxtlas may have involved scheduling conflicts (McCormack 2002).

In the absence of annually renewed river levees, Formative Tuxtla farmers would have had to practice shifting cultivation, alternating between fields located close to the residence and others located at a distance. Recently, Thomas Killion (1987, 1990) has examined subsistence farming as it relates to residential space among contemporary Tuxtla farmers, and has developed an ethnoarchaeological model relating agriculture to the organization of household labor and residential patterns. Specifically,

Killion (1987, 1990) links cultivation intensity (defined as the increasing frequency of cultivation on a constant area of land over time) with residential organization, presenting a farming system he refers to as “infield/outfield” cultivation. Infields refer to plots located near the settlement, and outfields to plots located at a distance from the settlement.

The form that the infield/outfield system takes in the Tuxtlas today varies with respect to local geography. Variation in rainfall and soil fertility between the northern and southern portions of the Tuxtlas has led to different strategies of intensification by contemporary Tuxtla farmers (Killion 1987). In the north, heavy rainfall throughout the wet season allows yearlong intensive crop production close to settlements (in infields). The southern region of the Tuxtlas, however, receives less than half the amount of rainfall experienced by the northern Tuxtlas.⁵ In the absence of irrigation, crop production in the south is less continuous throughout the year. Moreover, residences in the south tend to be located along upland interfluves where soils are less fertile. Farmers thus tend to cultivate crops that require fewer nutrients (tree orchards, for example) in the infields. Intensive cultivation, on the other hand, occurs in outfields located on the humid alluvial bottomlands.

Outfield cultivation requires travel and a temporary shelter away from the primary residence. When infields are cultivated more intensively than outfields, most farming tasks are conducted near or at the residence, including crop processing, tool manufacture/repair, and storage. When outfields are cultivated more intensively, farmers must perform harvest-related tasks in the fields, including initial processing, drying, bundling, and storage of crops. Thus, the spatial location of farm fields relative to the residence conditions the types of activities conducted at the residence, which in turn conditions the organization of residential space (Killion 1987).

Based on this relationship between the infield/outfield system and the organization of residential space in the modern Tuxtlas, Killion developed a model of residence that he terms the “houseslot” (Killion 1987; see also Killion 1990:202, Fig. 6). The houseslot consists of a structural core, a clear area, an intermediate area, and a garden. The structural core forms the central portion of the houseslot and consists of the residential structure(s). Surrounding the core is the clear area, defined by Killion as a multi-use space in which the bulk of domestic tasks are performed, including the drying, shelling, and cleaning of maize and beans. Because the clear area is primarily a high-activity zone, it is generally swept clean of refuse. The intermediate area encircles the clear area and is the space into

which refuse is swept and deposited. Finally, the garden area surrounds the intermediate area and acts as a border to the houselot. The garden is devoted to plants that are grown to supplement crops grown in the fields, and thus consists of a mix of ornamental and economically useful plants secondary to staple foods. This type of residential organization is ubiquitous throughout tropical Mesoamerica, and may also have been common prehistorically (see below).

Killion's (1987, 1990) quantitative analysis of 40 modern Tuxtleco households revealed additional insights into the relationship between agricultural and residential space. First, there appears to be a positive correlation between the size of the clear area and the level of cultivation intensity on infield plots—in other words, a larger activity area at the houselot indicates a focus on infield production (Killion 1990:205–205). This pattern supports the assumption that when infields are cultivated intensively, most farming-related tasks will be performed at the houselot, thus requiring a larger residential work area. Second, Killion's analysis yielded a negative correlation between the size of the intermediate (refuse) area and the level of cultivation intensity on infield plots—in other words, a smaller refuse area indicates a focus on infield production (Killion 1990:206–208). This might seem counterintuitive, in that a focus on infield production translates into more farming-related tasks occurring in residential space, which in turn produces more refuse. However, this negative correlation is largely a product of a high regional population density in modern times. With more people generating more refuse while living in closer proximity to one another, there is a greater need for waste to be transported further away from the houselot, which reduces the size of the intermediate (refuse) area. We might expect this relationship between infield production and the size of the refuse zone to have been positively correlated in the past, when regional population density was much lower. Nevertheless, Killion's analysis provides tangible expectations for understanding how residential space could have been organized in relation to infield/outfield cultivation during Formative times.

Formative Subsistence Economy in the Tuxtlas

Direct archaeological evidence of subsistence in the Formative Tuxtlas consists entirely of pollen data. Based on analysis of a pollen core extracted from Lago Catemaco in 1982, Byrne and Horne (1989) determined that *Zea* pollen was present throughout the Formative period. However, problems with the radiocarbon dating of the Lago Catemaco core sediments

complicated interpretations of a regional maize chronology (Byrne and Horne 1989; Goman and Byrne 1998). Laguna Pompal, located east of Lake Catemaco, was cored in 1992. The results of this pollen analysis indicate the presence of maize in the region by ca. 4830 BP (2780 BC), well before the Formative period (Goman 1992; Goman and Byrne 1998). These data represent the oldest evidence for maize in the Tuxtlas. Nevertheless, the pollen evidence indicates an absence of maize during the Early Formative and early Middle Formative periods, in addition to a decline in disturbance species within the vicinity of Laguna Pompal (Goman and Byrne 1998). By the end of the Middle Formative period, however, pollen from maize and weedy disturbance species becomes important in the record again. These data correlate well with the settlement patterns documented by Santley and colleagues (1997), in which Early Formative peoples located their residences along the lower reaches of the Catemaco River and its tributaries, away from the lake proper (see below).

Changing Settlement in the Tuxtlas

Recent settlement surveys by Santley and colleagues (Santley 1991; Santley and Arnold 1996; Santley et al. 1997) have laid the foundation for current archaeological research in the Sierra de los Tuxtlas.⁶ In the 1970s, Robert Santley began a project of combined survey and excavation, employing techniques similar to those used in the Basin of Mexico (Sanders et al. 1979) and the Valley of Oaxaca (Blanton et al. 1982). They surveyed an area of approximately 400 km², locating 182 sites representing 577 components (Santley et al. 1997).

The Early Formative period in the Tuxtlas is represented by 3 small villages and 21 hamlets (Figure 3.3). Two main clusters of settlement were identified; most of the sites were located near the Classic period site of Matacapan, the rest within the vicinity of Chuniapan de Abajo. Based on archaeological data from Matacapan and ethnoarchaeological data from Killion's study of contemporary Tuxtleco farmers, Santley (1992) has suggested a Formative farming strategy that included infield and kitchen garden cultivation. Low population densities during the Early Formative period, however, suggest that farming may have played a less significant role during the Early Formative than in later periods (Santley and Arnold 1996).

The Middle Formative period marked a nearly twofold increase in regional population, accompanied by a shift in settlement and an increase in site types (Figure 3.4; Santley et al. 1997). Arranged differently across the

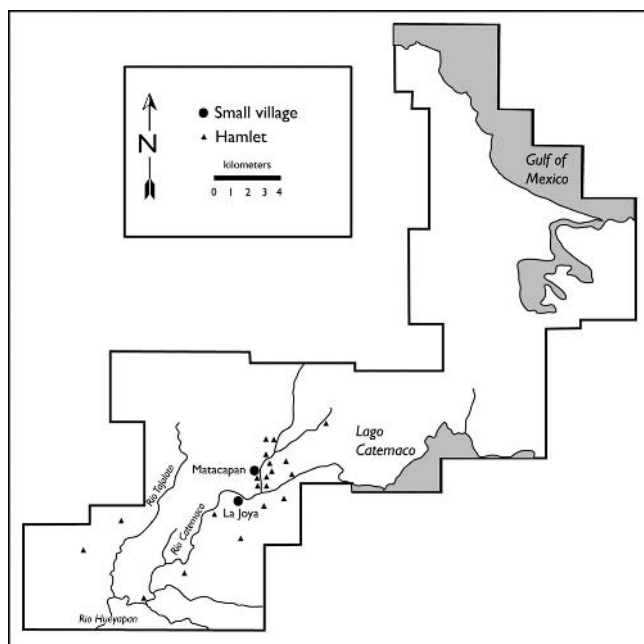


FIGURE 3.3. *Early Formative (EF) settlement patterns in the Sierra de los Tuxtlas.* (Modified from figure 7.3 in “Formative Period Settlement Patterns in the Tuxtla Mountains,” by Robert S. Santley, Philip J. Arnold III, and Thomas P. Barrett, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)

landscape than in the previous period, the Middle Formative sites cluster into three distinct groups—the first includes the large village site of La Joya and surrounding hamlets, the second is composed of a series of small villages and hamlets along the lower portions of the Catemaco and Tajalote Rivers, and the third includes the large village site of Teotepec and two hamlets in the northern Tuxtlas. The area around Matacapán was mostly abandoned by the end of the Middle Formative, with people moving their settlements south to the middle and lower reaches of the Catemaco River and its tributaries (Santley et al. 1997).

Forty-three Late Formative sites were identified as part of the survey, represented mostly by villages (Figure 3.5). One village site, Chuniapan de Abajo, seems to have been more nucleated than the other villages at this time. Although population levels changed little from the Middle For-

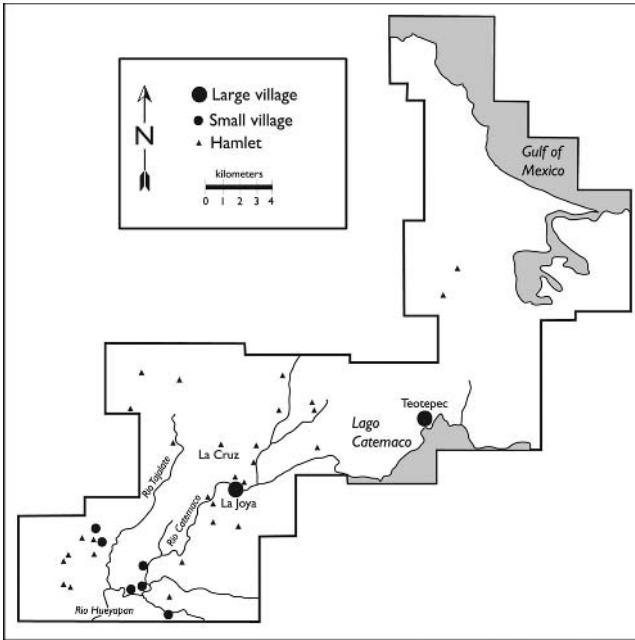


FIGURE 3.4. Middle Formative (MF) settlement patterns in the Sierra de los Tuxtlas. (Modified from figure 7.4 in "Formative Period Settlement Patterns in the Tuxtla Mountains," by Robert S. Santley, Philip J. Arnold III, and Thomas P. Barrett, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)

mative, the Late Formative period did witness a slight settlement shift into two main clusters of occupation—near Chuniapan de Abajo and northwest of Matacapán. Population levels dropped considerably by the Terminal Formative (Figure 3.6). Only 10 sites dating to this period were identified by the survey, again forming two main clusters—one in the extreme southern part of the region, and the other in the uplands northwest of Matacapán. In the southern cluster, a regional center appears to have emerged at the site of Chuniapan de Arriba.

Santley and colleagues (Santley et al. 1997) attribute these shifts in settlement location to volcanism. Volcanic eruptions during the Early, Late, and Terminal Formative periods would have blanketed the lands in and around Matacapán with layers of volcanic ash. Less affected by volcanic ash would have been areas farther downstream on the Catemaco

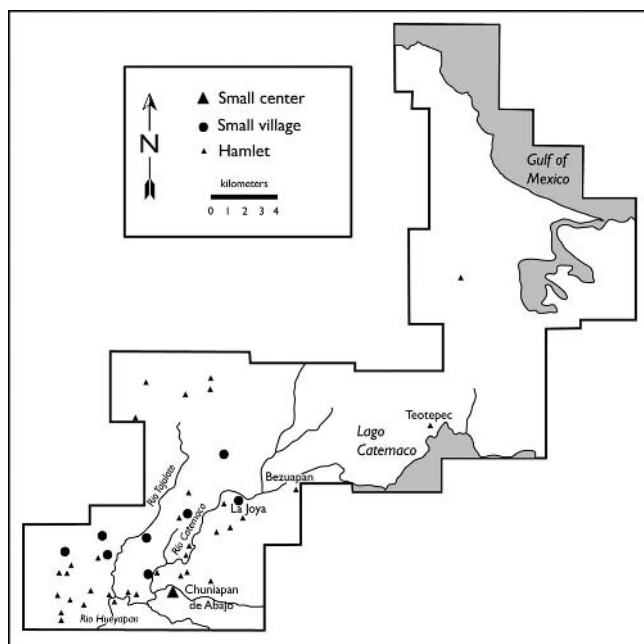


FIGURE 3.5. *Late Formative (LF) settlement patterns in the Sierra de los Tuxtlas.* (Modified from figure 7.5 in “Formative Period Settlement Patterns in the Tuxtla Mountains,” by Robert S. Santley, Philip J. Arnold III, and Thomas P. Barrett, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)

River and its tributaries. Given the adverse effect that ashfall would have had on maize productivity and the collection of local food resources in the short term, it is no wonder people moved their settlements at the end of the Early Formative.

In addition to the identification of settlement shifts, regional survey data also provide information regarding settlement hierarchy. During the Early Formative, the Tuxtla regional site hierarchy was composed only of villages and hamlets. By the Middle Formative, people began to aggregate into larger villages and mounded architecture appeared, but sites remained functionally undifferentiated (Santley et al. 1997). Given these data, social organization in the Tuxtlas during the Early and Middle Formative has been characterized as relatively egalitarian with only minor socioeconomic differentiation (Santley et al. 1997). During the Late Formative, a small regional center emerged at the site of Chuniapan de Abajo,

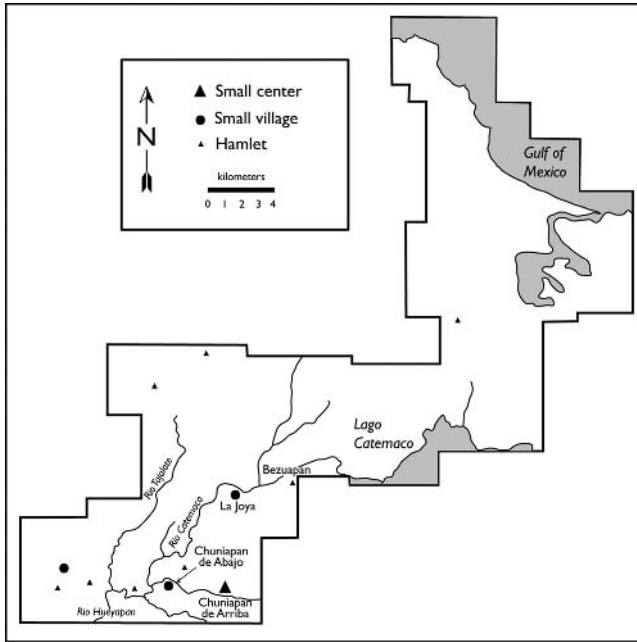


FIGURE 3.6. Terminal Formative (TF) settlement patterns in the Sierra de los Tuxtlas. (Modified from figure 7.6 in "Formative Period Settlement Patterns in the Tuxtla Mountains," by Robert S. Santley, Philip J. Arnold III, and Thomas P. Barrett, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)

although most people still resided in small villages and hamlets. This period may mark the beginnings of a differentiated sociopolitical system, with Chuniapan de Abajo representing a level of hierarchy above the village tier (Santley et al. 1997). Arnold, however, has observed that much of the material recovered from Chuniapan de Abajo postdates the Formative period, which calls into question the classification of this site as a regional center during this time (Arnold 2002, pers. comm.). A three-tiered settlement hierarchy has also been identified during the Terminal Formative period, with a regional political center located at the site of Chuniapan de Arriba (Santley et al. 1997: 183).

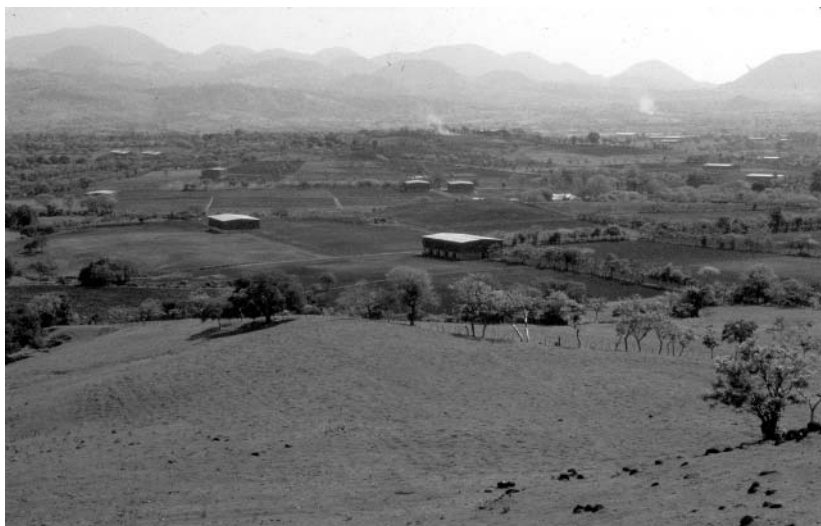
Both Stark (1997) and Pool (2000) have alluded to increasing regional political fragmentation during the Terminal Formative period. Indeed, the Terminal Formative period in the Tuxtlas is marked by a radical decrease in regional population. Nevertheless, settlement data indicate the

continued presence of a three-tiered regional political hierarchy during this time (Santley et al. 1997). Santley et al. (1997) link this episode of regional depopulation with volcanic activity during the Late and Terminal Formative periods (see above). The implication is that volcanic eruptions and their aftereffects were severe enough that many of the regional inhabitants chose to leave. But why did some people choose to flee the region, while others chose to stay? Though volcanic ash may affect the entire area surrounding the blast, it does not fall in a homogeneous fashion—because of wind and precipitation, areas will be differentially affected. Were the people who left the region living at sites that were the most severely affected by ashfall? Possibly. However, excavations at the study sites reveal extensive ashfall, and yet these sites were reoccupied (see below). The decision to stay or to go may have been based in part on the degree to which people were integrated into the regional political hierarchy. That is, those people who chose to stay in the Tuxtlas following environmental catastrophe may have had stronger ties to the regional political system. Perhaps regional elites offered benefits and incentives for people to stay, or perhaps people simply remained out of a sense of obligation to their leaders (e.g., tribute demands). While we may never know the full range of factors that influenced people's decisions about staying or going, we can be relatively certain that people were probably motivated by a combination of environmental and political factors.

Descriptions of the Study Sites

The sites of La Joya and Bezuapan both represent sizable Formative occupations in this region (see Figure 3.2). Excavations at these sites uncovered substantial evidence of domestic occupation, including house structures, hearths, and storage pits. Because the directors of these projects were both interested in focusing on the household as the basic analytic unit, data were collected to enable fine-grained spatial analyses. This section provides an overview of what we have learned to date regarding the development of social and residential organization at these important Formative sites.

La Joya. La Joya was excavated by Philip Arnold III during 1995 and 1996. The site covers approximately 25 hectares and is located on the alluvial flatlands along the Catemaco River in the southern portion of the Tuxtlas (Figure 3.7). La Joya was occupied throughout the Formative period, al-



PHOTOGRAPH 3.1. *The site of La Joya. (Photograph courtesy of Philip J. Arnold III.)*

though settlement intensity varies over the site's history. Recent ceramic analysis by Arnold (1999) has revealed a gradual stylistic change indicative of an *in situ* cultural transition. In other words, residents of Formative period La Joya were not colonists sent from the lowland Olmec centers to set up camp.

Radiocarbon dates from La Joya reveal that the site was occupied throughout the Formative period, in addition to an Early Classic component (Table 3.1; Arnold 2002). The Early Formative represents 450 years of occupation and can be divided into three phases based on radiocarbon dates and stylistic changes in ceramics. The Tulipan phase (1300–1150 BC) is the earliest occupation at the site and corresponds to the Ojochi and Bajío phases at the San Lorenzo site (Arnold 2002). The Tulipan and Coyame occupations were separated by 8–10 cm of volcanic ash (Arnold 2002, pers. comm.). The Coyame phase is contemporaneous with the Olmec manifestation at San Lorenzo, and La Joya ceramics from this phase are broadly similar to those from San Lorenzo (Arnold 2002). Arnold (2002) subdivided the Coyame phase into two subphases, A and B (1150–1000 BC and 1000–850 BC, respectively), based on subtle temporal differences in the ceramic assemblages. The division between Coyame A and B also reflects an increase in the site's occupation intensity (Arnold 2002; McCormack 2002). Because of the generally small samples of sub-

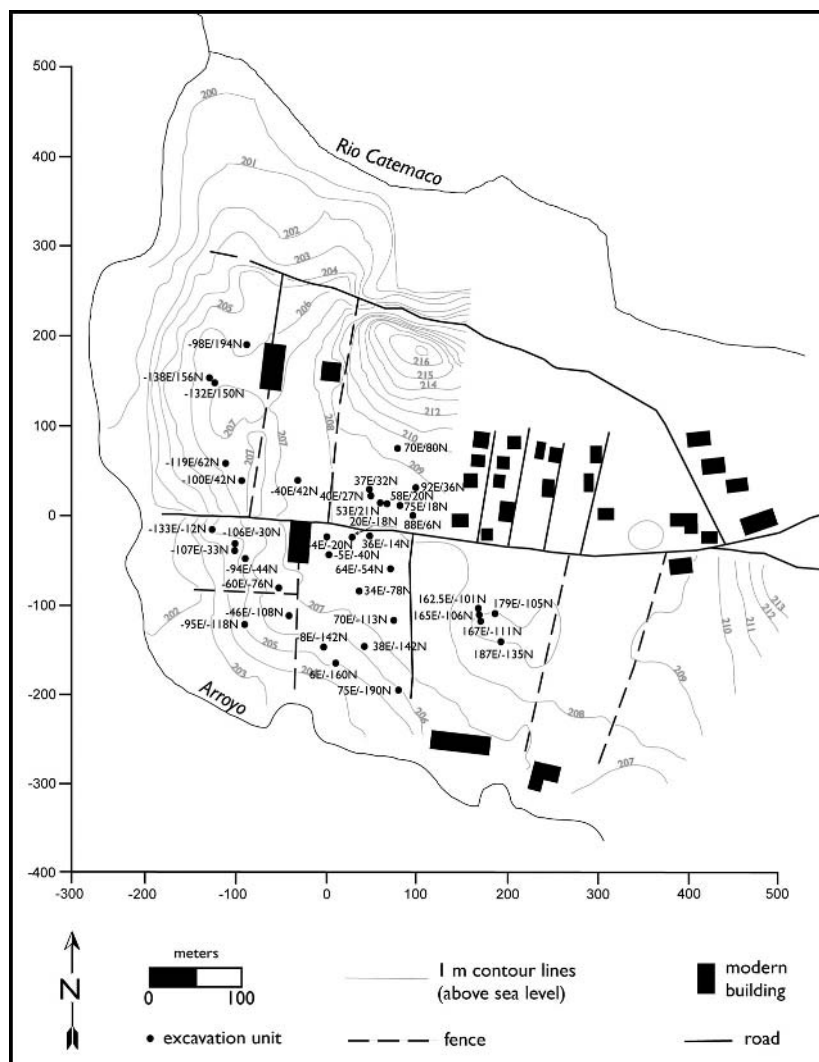


FIGURE 3.7. Location of excavation units at La Joya.

sistence remains from the site and because not all Early Formative contexts could be assigned to one of these subphases, I group plant and animal remains from these three phases together as Early Formative.

The Middle Formative period at La Joya, or the Gordita phase, represents approximately 450 years of occupation (850–400 BC). The Middle Formative period is poorly represented at La Joya, which probably re-

TABLE 3.1. RADIOCARBON DATES FOR LA JOYA (ARNOLD 2002)

<i>Period</i>	<i>Phase</i>	<i>Age</i>	<i>Cal. 1-Sigma</i>	<i>Cal. 2-Sigma</i>
Early Classic (EC)		1595 ± 81	AD 398–559	AD 325–635
Terminal	Late Bezuapan	1605 ± 55	AD 420–536	AD 341–599
Formative (TF)	Late Bezuapan	1650 ± 55	AD 340–452	AD 320–544
	Late Bezuapan	1660 ± 55	AD 332–447	AD 317–540
Late	Early Bezuapan	1885 ± 60	AD 80–215	AD 8–254
Formative (LF)	Early Bezuapan	1915 ± 75	AD 13–212	89 BC–AD 255
	Early Bezuapan	1960 ± 60	28 BC–AD 122	96 BC–AD 181
	Early Bezuapan	2110 ± 55	195–53 BC	355 BC–AD 13
	Early Bezuapan	2110 ± 55	195–53 BC	355 BC–AD 13
Middle	Gordita	2290 ± 237	552–59 BC	859 BC–AD 223
Formative (MF)	Gordita	2627 ± 159	927–515 BC	1135–382 BC
	Gordita	2735 ± 55	911–820 BC	947–804 BC
Early	Coyame B	2754 ± 263	1265–755 BC	1524–352 BC
Formative (EF)	Coyame B	2876 ± 170	1260–864 BC	1515–762 BC
	Coyame B	2905 ± 60	1164–994 BC	1206–919 BC
	Coyame B	2950 ± 55	1257–1053 BC	1371–1001 BC
	Coyame A	3005 ± 60	1312–1154 BC	1395–1047 BC
	Coyame A	3015 ± 60	1315–1161 BC	1402–1110 BC
	Coyame A	3055 ± 85	1411–1194 BC	1498–1049 BC
	Coyame A	3050 ± 60	1394–1220 BC	1432–1125 BC
	Coyame A	3050 ± 60	1394–1220 BC	1432–1125 BC
	Tulipan	3165 ± 55	1510–1394 BC	1523–1229 BC

flects a sparser occupation during this time (Arnold 2002). The Late Formative period at La Joya, or the Early Bezuapan phase (see Pool and Britt 2000), represents a span of time comparable in length to the Middle Formative period (400 BC–AD 100). Unlike the Early through Late Formative periods that represent approximately 400-year blocks, the Terminal Formative period, or Late Bezuapan phase, represents at most 250 years (AD 100–350). Both the Late and Terminal Formative periods are marked by an increase in settlement density at the site (see below). Despite regional evidence for a volcanic eruption during the Late Formative period (about 150 BC), the absence of ash in the Late Formative deposits at La Joya indicate that the site's residents were not directly affected by this eruption.

During the Terminal Formative period, however, another eruption (AD 150–250) blanketed the site in 10–15 cm of ash (Arnold 2002, pers. comm.). This layer of volcanic ash separates the Terminal Formative occupation from the subsequent Early Classic occupation. The site was abandoned at the end of the Terminal Formative period, in response to volcanic eruptions. The site was reoccupied during the subsequent Early Classic period by a different group of people. Major changes in material culture from the Terminal Formative to Early Classic periods indicate an influx of foreigners from Teotihuacan into the Tuxtla (Arnold 2002; Pool and Britt 2000).

Analysis of artifacts and architecture through the site's occupational history reveals little evidence of status differentiation during the Early or Middle Formative period (McCormack 2002). Indeed, evidence of social ranking does not appear until the Late Formative period, and was never as pronounced as among the lowland Olmec (McCormack 2002). Analysis of residential patterns from La Joya indicates that the site's residents were sedentary by the end of the Early Formative period (McCormack 2002: 192). Prior to that, people were moving seasonally or annually, occupying multiple locations (Arnold 2000; McCormack 2002). Architecture during this time was mostly ephemeral, consisting mainly of "packed earthen surfaces" with associated low-density sheet midden (Arnold 2000: 126). McCormack (2002: 192) relates the transition toward sedentism at the end of the Early Formative to the eruption of Cerro Mono Blanco around 1250–900 BC. La Joya was located along the edge of the area impacted by the eruption, which may have influenced the decision to settle down (McCormack 2002). By the Late Formative period, architecture was more substantial and included a small residential mound approximately 1 m high (Arnold 2000; Arnold et al. 1992).

Thus far, indirect evidence of subsistence suggests an increasing reliance on maize throughout the site's occupation. An increase in the presence and size of subsurface storage pits from the Early to Late Formative periods indicates that La Joya residents may have been producing, accumulating, and storing more maize through time (see Arnold 2000). Moreover, the remains of ridged agricultural fields were identified in several excavation units—these fields were overlaid with a layer of volcanic ash from the Terminal Formative eruption (Arnold 2000). Thus, by the end of Terminal Formative period, residents of La Joya were farming intensively.

Analysis of ground stone from La Joya demonstrates that the design and use of grinding tools became more specialized from the Early to Middle

Formative periods (Arnold 2000: 127; McCormack 2002: 169). McCormack (2002; 175, 178) has identified a shift from one- to two-handed manos and an increase in the quantity of two-sided metates from the Early to Late Formative periods—both patterns suggest an increase in the use of grinding implements, which likely reflects an increase in maize processing (see also Arnold 2000: 127). Moreover, an increase in the use of naturally rougher (vesicular) basalt through time also indicates more intensive maize processing (McCormack 2002). Taken together, these changes in the La Joya ground stone assemblage suggest a shift to a set of tools geared toward maize processing. Analysis of the subsistence data will provide a natural complement to the ground stone data.

Overall, the evidence from La Joya reveals a long history of settlement marked by increases in sedentism, maize reliance, and social differentiation. Throughout the site's tenure, people began to settle down and eventually intensify maize production. The emergence of social differentiation at the site during the Late Formative occurs within the context of regional political change—a three-tiered settlement hierarchy emerged at this time, centered at Chuniapan de Abajo. How closely were the residents of La Joya integrated into this regional political system? Were people dependent on regional elites for access to esoteric media? Did they provide tribute to regional elites in the form of food and/or labor? Lithic evidence from La Joya reveals that the site's Late Formative residents were procuring nonlocal obsidian from several sources (McCormack 1996). Moreover, the high percentage of obsidian debitage relative to finished blades at La Joya suggests that people were producing obsidian blades on-site (McCormack 1996). These data suggest that the people living at La Joya maintained their own obsidian exchange networks and thus were not dependent on regional elites for access to long-distance exchange (McCormack 1996). But were La Joya residents obligated to provide tribute to regional leaders? An increase in storage area through time suggests that people were producing and storing surplus maize (see above). Whether or not residents of La Joya supplied regional elites with some of this surplus, however, must be tested with the subsistence data.

Bezuapan. Bezuapan, excavated by Christopher Pool in 1986 and 1993, is located just 5 km east of La Joya along the Bezuapan River. Excavations at Bezuapan were less extensive than at La Joya, focusing on a series of stratigraphically stacked house structures. Unlike La Joya, Bezuapan does not span the entire Formative sequence. The site was initially settled during the Late Formative, a period marking the development of a regional



PHOTOGRAPH 3.2. *The site of Bezuapan, view to east. (Photograph courtesy of Christopher A. Pool.)*

political hierarchy in the region. Investigations at the site have revealed a series of four occupations, two of which were sealed with layers of volcanic ash (Pool 1997; Pool and Britt 2000). Radiocarbon dates and ceramic indicators place these four occupations during the Late Formative, Terminal Formative, and Classic periods (Pool and Britt 2000). Overall, the settlement at Bezuapan can be characterized by occupations that have shorter durations than settlement at La Joya.

Because the occupations at Bezuapan represent such narrow time spans, radiocarbon dates from each occupation overlap considerably (Table 3.2). The Late Formative occupation at Bezuapan dates to ca. 505–205 BC, with a calibrated intercept of 390 BC (Table 3.2; see also Pool and Britt 2000). Excavations of this occupation uncovered the remains of a wattle-and-daub structure and a hard-packed earthen floor (Figure 3.8; Pool 1997:50; Pool and Britt 2000:143). There is no direct evidence of food storage at this time, indicated by a lack of subterranean pits and aboveground storehouses (Pool 1997). Pool (1997:56) argues that the “nondurable” wattle-and-daub house construction, the lack of modification to structure walls or floors, and the lack of storage facilities indicates that the Late Formative occupation was relatively short-lived, probably

TABLE 3.2. RADIOCARBON DATES FOR BEZUAPAN
(POOL AND BRITT 2000)

Period	Phase	Age	Cal. 1-Sigma	Cal. 2-Sigma
Terminal Formative (TF-II)	Late Bezuapan (Occupation III)	1760 ± 90	AD 160–405	AD 75–465, AD 475–515
		1780 ± 80	AD 145–380	AD 75–430
		1810 ± 70	AD 130–330	AD 70–405
Terminal Formative (TF-I)	Late Bezuapan (Occupation II)	1790 ± 90	AD 130–380	AD 55–435
		1920 ± 90	AD 5–220	100 BC–BC 330
Late Formative (LF)	Early Bezuapan (Occupation I)	2320 ± 120	505–205 BC	785–60 BC

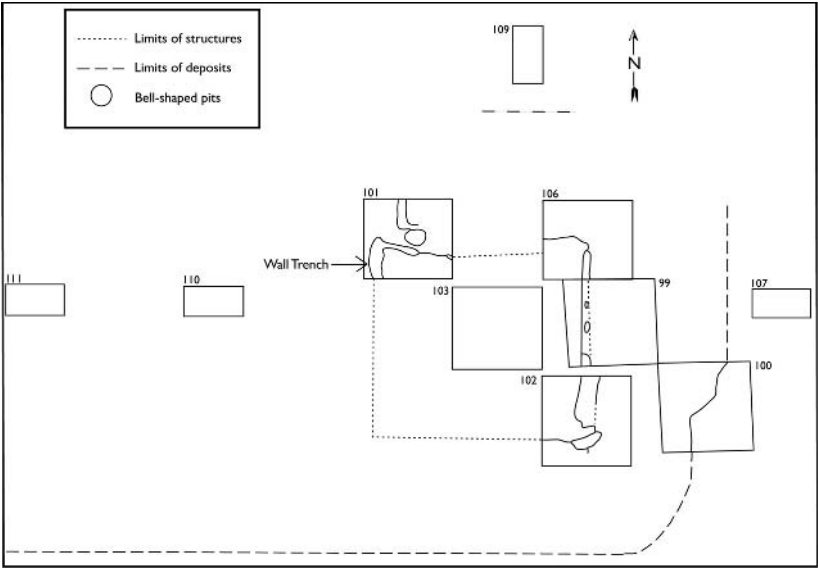


FIGURE 3.8. Late Formative (LF) occupation at Bezuapan. (Modified from figure 2.3 in “The Spatial Structure of Formative Houselots at Bezuapan,” by Christopher A. Pool, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)

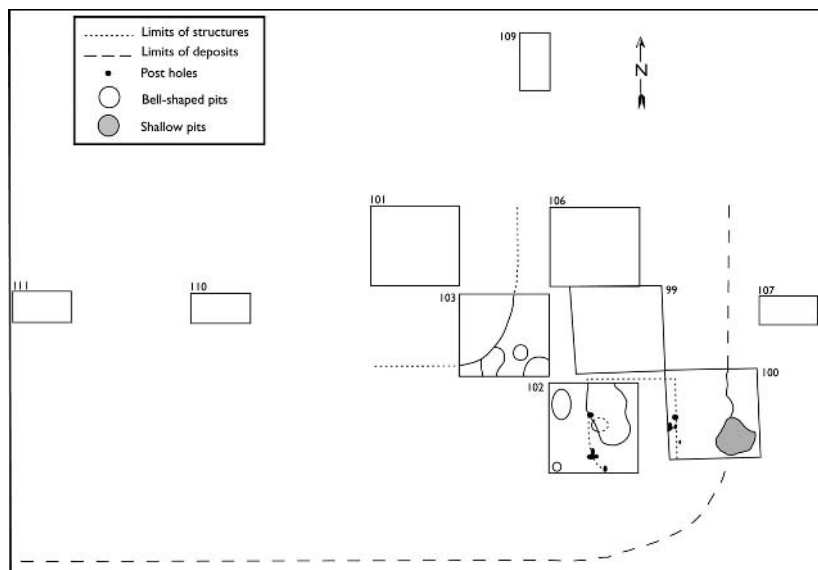


FIGURE 3.9. *Terminal Formative I (TF-I) occupation at Bezuapan. (Modified from figure 2.4 in “The Spatial Structure of Formative Houselots at Bezuapan,” by Christopher A. Pool, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)*

representing a single generation. This Late Formative structure was abandoned rapidly after it burned (Pool 1997).

The Terminal Formative period at Bezuapan is represented by two consecutive occupations (Figures 3.9, 3.10). The initial Terminal Formative occupation dates to the first few centuries AD—the radiocarbon samples yielded calibrated intercepts of AD 90 and AD 245 (Pool and Britt 2000: 145). This phase of settlement marks the adoption of a new, more substantial house construction technique—people shifted from wattle-and-daub to pole-and-thatch construction (Pool 1997: 52; Pool and Britt 2000: 143). Several subterranean storage pits, in addition to a possible aboveground storehouse, were associated with this structure (Pool 1997: 52; Pool and Britt 2000: 143). The first Terminal Formative occupation at Bezuapan was abandoned following a volcanic eruption. Deposits from this occupation were covered with thin lenses of volcanic ash (Figure 3.11; Pool 1997; Pool and Britt 2000).

Bezuapan was reoccupied shortly after its abandonment as a result of ashfall. Radiocarbon samples from the second Terminal Formative occu-

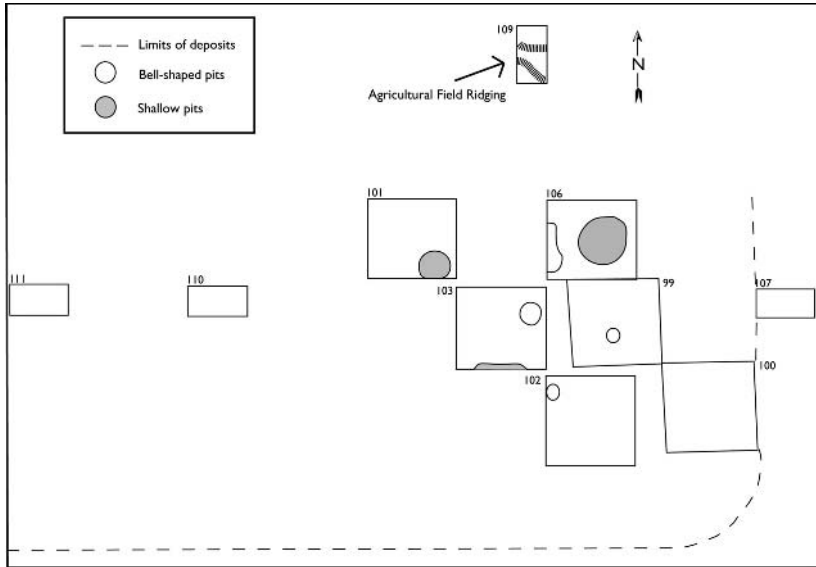


FIGURE 3.10. *Terminal Formative II (TF-II) occupation at Bezuapan. (Modified from figure 2.5 in "The Spatial Structure of Formative Houselots at Bezuapan," by Christopher A. Pool, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)*

pation yielded calibrated intercepts of AD 235, AD 245, and AD 260 (Pool and Britt 2000: 145). No structural remains from the final Formative occupation were encountered, but excavations did uncover two shallow pits and four bell-shaped pits (Pool 1997: 54; Pool and Britt 2000: 143). The increase in subterranean pits during this time indicates an increase in the use of storage facilities, probably for maize surpluses. Moreover, excavations in the northern part of the site uncovered a ridged agricultural field dating to this period (Pool 1997: 54). The presence of this ridged surface indicates that the Terminal Formative residents of Bezuapan were employing an intensive cultivation strategy. The site was again abandoned following a major volcanic eruption in the region. This second eruption blanketed the site with approximately 120 cm of ash—it was this layer of ash that preserved the ridged agricultural field encountered during excavations (Figure 3.11).

In addition to radiocarbon dates, ceramic evidence indicates that each occupation lasted a relatively short time (Pool and Britt 2000). These relatively brief occupations, coupled with rapid abandonment subsequent to

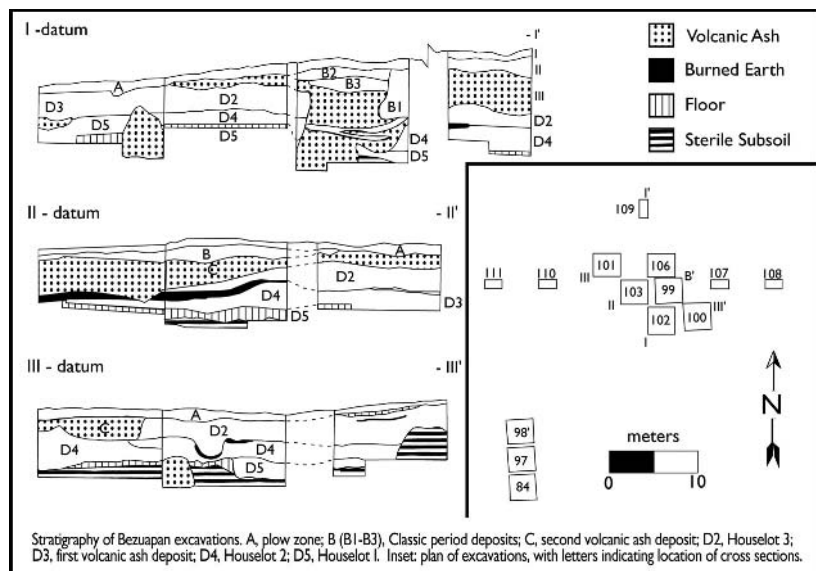


FIGURE 3.1.1. *Stratigraphic profiles of excavation units at Bezuapan.* (Modified from figure 2.6 in “The Spatial Structure of Formative Houselots at Bezuapan,” by Christopher A. Pool, from *Olmec to Aztec: Settlement Patterns in the Ancient Gulf Lowlands*, edited by Barbara L. Stark and Philip J. Arnold III, © 1997 The Arizona Board of Regents. Reprinted by permission of the University of Arizona Press.)

structure burning and volcanic ashfalls, make it possible to directly associate construction episodes, activity areas, and refuse deposits with one another (Pool 1997; Pool and Britt 2000). The direct association between these different types of deposits has allowed for a fine-grained household-level spatial analysis (Pool 1997).

Informed by Killion’s houselot model, Pool has reconstructed the organization of household space at Bezuapan through an analysis of artifactual densities from different areas within and around the residential structures. Pool’s analysis reveals the presence of an extensive clear area surrounding the structural core. This clear space probably functioned as a diversified activity area (Pool 1997; see also Killion 1987). Low artifact densities from this zone indicate that it was “intensively maintained” and “kept relatively free of debris that might have interfered with the activities performed there” (Pool 1997:59). Refuse generated from activities conducted in this clear area was swept away from the structural core, resulting in a concentric ring of midden, or what Killion refers to as the intermediate area, bounding the clear area (Pool 1997:59). A ridged field

identified during excavations lay beyond the intermediate/refuse zone, representing either an infield or kitchen garden (Pool 1997:59). The large size of the clear area, coupled with the identification of a ridged field near the houselot, suggests that Bezuapan residents focused their agricultural production on infields (Pool 1997:61). As Killion has demonstrated (see above), there is a positive correlation between the size of the clear area and the level of infield cultivation—the implication is that the cultivation of fields near the houselot (infields) requires a larger (clear) area for farming-related tasks at the houselot than does the cultivation of fields further away from the houselot (outfields). Pool (1997:61) argues that the focus on infield production at Bezuapan was structured in part by low population densities relative to modern times. In other words, there was no shortage of farmland, making it possible to focus production on fields located close to the houselot.

Finally, it is notable that Bezuapan was part of a regional settlement system that included the first regional center at Chuniapan de Abajo during the Late Formative and a subsequent regional center at Chuniapan de Arriba during the Terminal Formative period. Evidence of greater access to long-distance obsidian exchange and an increase in storage area (see above) during the Terminal Formative period suggest a greater degree of social differentiation for Bezuapan residents during this time (Pool 1997). The increased access to obsidian by Bezuapan residents, in addition to the lack of obsidian production evidence at Bezuapan (McCormack 1996), may reflect their level of integration into the regional political hierarchy—unlike at La Joya, residents of Bezuapan likely procured finished obsidian blades from elites who had access to long-distance trade networks (Pool 1997). The increase in storage through time probably reflects an increase in the accumulation of surplus maize. Pool (1997:64) has suggested that regional elites may have encouraged villagers at Bezuapan to mobilize surplus agricultural foodstuffs to be funneled toward these regional centers. Whether or not this was the case, however, remains to be discovered through an examination of the subsistence data.

DISCUSSION: FARMING AND POLITICS IN THE TUXTLAS

Much time and energy have been expended researching the rise of Olmec society in the lowlands (Bove 1978; Caso 1965; Coe and Diehl 1980b; Diehl 1989; Earle 1976; Heizer 1960, 1962). Unfortunately, most explanatory frameworks are based on too few data. Nevertheless, the data are slowly catching up with the models, producing a fuller picture of Olmec

political development. Using a household-centered approach, Tuxtla researchers have busied themselves collecting the fine-grained data necessary to piece together Formative developments in this mountainous region. Thus, we are only just beginning to understand larger regional developments, such as the timing and interrelationship between sedentism, the transition from foraging to farming, and the emergence of political complexity. Nevertheless, it is clear that these processes differed with respect to the lowlands and the Tuxtlas.

In the lowlands, the juxtaposition of prime farmland with aquatic resource zones provided Early Formative Olmecs with a stable and predictable food base that could easily support sedentary populations. Differential access to these overlapping resource zones may have allowed certain groups near San Lorenzo to gain power over the larger populace (Borstein 2001; McCormack 2002). Maize probably did not become the mainstay of the lowland subsistence economy until after the Olmec rose to power.⁷ Thus, the emergence of political complexity in the lowlands was not founded on a farming-focused subsistence economy. Rather, the unique ecology of the region enabled some individuals or groups to fund their quest for power based on a mixed subsistence economy.

In the Tuxtlas, people were relatively egalitarian until the Late Formative period, well after the collapse of San Lorenzo and La Venta. Unlike in the lowlands, Tuxtla residents did not become fully sedentary until the end of the Early Formative period, after maize had already become productive enough to warrant staple cultivation (see above). This shift to sedentism is also coincident with a volcanic eruption from Cerro Mono Blanco that likely restricted people's foraging mobility. Because resources are more dispersed in the Tuxtlas than in the lowlands, greater mobility would have been necessary to maintain a mixed subsistence economy. Thus, it appears that Tuxtla residents may have become more focused on farming toward the end of the Early Formative, prior to the emergence of a regional political hierarchy.

The processes leading to increasing social differentiation and the emergence of chiefdoms in the Tuxtlas during the Late Formative period are still unclear. The establishment of a political center at Tres Zapotes, in the foothills of the Tuxtlas, during this time may have affected local political development. What is also unclear is the nature of the relationship between Early and Middle Formative Tuxtla residents and lowland Olmec peoples. These people were not unaware of each other—they shared similar ceramic traditions, and all of the basalt used for Olmec monuments and grinding tools came from Cerro Cintepéc, only 5–6 km south

of Lago Catemaco. Understanding the connections between the Olmec heartland and the Tuxtlas requires that we first understand independent developments within each region. To this end, the following chapters explore the relationship between Formative subsistence economy and the development of political complexity in the Tuxtlas through an examination of plant, animal, and stable isotopic data from the sites of La Joya and Bezuapan.

FARMING, GARDENING,
AND TREE MANAGEMENT:
ANALYSIS OF THE PLANT DATA

Understanding an agricultural system requires knowledge of the ways in which people interact with the plants and animals in their environment, as well as the causes and consequences of their manipulation of natural surroundings. Archaeologically, we can explore these issues through an examination of the remains of plants and animals within the context of analogy to modern ecology and anthropogenic change. This chapter focuses on the botanical side of Formative farming in the Tuxtlas—I focus more on the Formative occupations of the study sites than the subsequent Classic occupations. I begin with a discussion of methods, including procedures for recovery, laboratory analysis, and quantification. I then present the plants identified in the La Joya and Bezuapan assemblages to set the stage for my quantitative analysis. This section includes detailed ecological descriptions of the foods themselves as a background for reconstructing the manner in which people organized their agricultural system during the Formative period. Next, I present my quantitative analysis as a means to explore changes in the patterns of plant use through time. The final sections reconstruct the organization of the Formative farming system on the ground (in terms of field cropping, the home garden, and the management of tree resources) and place the archaeobotanical data in the context of regional political and environmental change.

METHODS OF ANALYSIS

In tropical open-air settings, archaeological plant and animal assemblages represent only a small fraction of what was used and deposited by humans. Natural and cultural factors can significantly modify organic remains, resulting in recovered assemblages that differ dramatically from the original deposits. As archaeologists, we examine collections that have undergone a series of processes—from the initial selection of plants and animals by humans, to food processing, cooking, discard, animal and insect scavenging, burial, decay, and weathering, and finally to the recovery of food resi-

dues through excavation. Using standard procedures for recovery, sampling, quantification, and analysis allows us to make sense of our assemblages in spite of the deleterious effects of these processes. Of course, despite the use of standardized methods, depositional and recovery processes still introduce biases that are often difficult to deal with. Nevertheless, a clear understanding of the processes affecting organic assemblages and a careful application of standard methods to these assemblages has the potential to afford us a general understanding of past subsistence.

Field Recovery Procedures

All units excavated at La Joya were dug in 10-cm levels within natural strata. All soil (except for soil samples taken for flotation) was dry screened through 0.25-inch mesh. A total of 4,585 bones weighing 2,920 g were recovered through screening. More than 600 soil samples were taken for flotation from contexts that appeared to have cultural integrity, including pit features and activity surfaces. The volume of soil sampled was not standardized, but it was systematically recorded, with most samples measuring 3–8 L. Soil was floated using a machine-assisted system that involved a 50-gallon barrel with the top removed. A hose inserted in the bottom half of the barrel, in combination with an elbow pipe, provided a constant spray of liquid midway up the barrel. The light fraction was captured as the water overflowed through a spout into a modified bucket—the bottom of the bucket was replaced with a fine-mesh window screen (Arnold 2002, pers. comm.). The heavy fraction was captured using a modified washbasin—the bottom of the basin was replaced with 0.06-inch window screen.

As at La Joya, all units at Bezuapan were excavated in 10-cm levels within natural strata. Not all soil was screened, however. The northwest 1×1 m square within each 3×3 m unit was designated as the screening square. Each 10-cm level within designated screening squares, as well as each stratigraphic zone within each feature, was screened separately through 0.25-inch mesh, yielding a total of 1,644 bones weighing 1,835 g. A total of 104 flotation samples were collected as column samples within features and units. Soil volume was standardized to 9 L, unless features were too small to permit a sample that large. If a feature was excessively deep, flotation samples were collected from each 10-cm level. Soil samples were floated without the aid of a machine-assisted system. Samples were floated in a bucket of water and agitated by hand. The light fraction was captured in a fine-weave synthetic cloth attached to the end

of a spout through which the water overflowed. The heavy fraction was captured using window screen (probably 0.06-inch mesh) (Pool 2002, pers. comm.).

It is obvious from these descriptions that recovery techniques were not the same at both sites, which makes direct comparisons between these two sites difficult. Thus, I focus on temporal trends within the data and consider the sites independently of one another. While this makes it impossible to directly assess whether particular subsistence activities were more or less prevalent at La Joya than at Bezuapan, a consideration of temporal trends within each site can provide a means by which to ascertain changes in subsistence at the site level. These changes in subsistence can then be compared on an interpretive level.

Recovery and Preservation Bias

The circumstances under which plants preserve best archaeologically involve extreme conditions (e.g., exceptionally wet, dry, or cold environments) that prohibit decomposition of organic matter (Miksicek 1987). Plants can also preserve through exposure to fire, which can transform plant material from organic matter into carbon (Miksicek 1987). Once plant material is carbonized, it is resistant to decay wrought by micro-organisms. Carbonized plant material is subject to mechanical damage, caused by processes such as trampling, repeated wetting/drying, or freezing/thawing. The type and extent of mechanical damage experienced by carbonized plant material can vary depending on local conditions. Preservation of plant remains in tropical environments is almost always restricted to carbonized specimens that are often highly fragmented (Pearshall 1995b).

The likelihood that a plant will become carbonized varies according to the type of plant, how it is prepared and used, and whether it has a dense or fragile structure (Scarry 1986). Plant parts that are eaten whole are less likely to produce discarded portions that may find their way into a fire. Plants that require the removal of inedible portions (e.g., avocado pits, maize cobs) are more likely to find their way into a fire, and thus into the archaeological record. Inedible plant parts represent intentional discard that is often burned as fuel. Moreover, because inedible portions tend to be dense and fibrous, they are more likely to survive the process of carbonization than the edible parts (e.g., avocado pits vs. avocado meat). Physical characteristics are also important for determining whether or not a plant will survive a fire. Large, dense avocado pits are more likely to

survive a fire than smaller, more fragile grass seeds. Food preparation activities also affect potential plant carbonization. The simple process of cooking provides the opportunity for carbonization through cooking accidents. Foods that are conventionally eaten raw, however, are less likely to be deposited in fires than cooked foods.

Some plants that find their way into the archaeological record in carbonized form were not eaten at all. Wood fuel is the most obvious example. Burned house structures can also yield carbonized plant deposits, and these deposits often differ dramatically from refuse deposits (Scarry 1986). Other nonfood plants that become carbonized are incidental inclusions, such as seeds blown by wind dispersal (Miksicek 1987; Minnis 1981; Scarry 1986). Indeed, most secondary invaders are weedy species with lots of seeds (e.g., cheno-am plants) (Minnis 1981). The presence and/or relative increase of such disturbance species can be indicators of forest clearing for agricultural fields. As Minnis (1981: 144) notes, "[T]he greater the disturbance to the soil, the greater the seed production, so that generally more seeds are produced in agricultural fields than in mature forests."

While we cannot know the absolute quantities or importance of different plants in any past subsistence economy, the preservation and recovery biases discussed above do not prohibit quantitative analyses of archaeobotanical assemblages. The most commonly used plant resources in any subsistence economy are more likely to be subject to activities that result in carbonization (e.g., through fuel use and accidental burning) and ultimately deposition (Scarry 1986; Yarnell 1982). Thus, we can quantitatively examine the relative importance of commonly used plant resources through time and across space.

Laboratory Procedures

Because the project encompassed both archaeobotanical and zooarchaeological analysis from two archaeological sites and because over 600 flotation samples were collected at La Joya, it seemed prudent to formulate a sampling strategy for the La Joya flotation samples. Therefore, I selected flotation samples from all features and well-defined activity areas for analysis ($n = 318$). All flotation samples taken from the site of Bezuapan were included in the analysis ($n = 104$).

Both the light and heavy fractions of the flotation samples were analyzed. Although the materials from the light and heavy fractions were processed and sorted separately, data from the two fractions were com-

bined for analysis. According to standard practice, the light fractions were weighed and then sifted through 2.0-mm, 1.4-mm, and 0.7-mm geological sieves. Carbonized plant remains were sorted in entirety down to the 0.7-mm sieve size with the aid of a stereoscopic microscope (10–40×). While most archaeobotanical analyses only scan for small seeds beyond the 2.0-mm or 1.4-mm sieve size, most of the maize kernel and cupule fragments present in the La Joya samples were smaller than 1.4 mm. Thus, I chose to sort all carbonized plant remains from both La Joya and Bezuapan down to the 0.7-mm sieve size. Residue less than 0.7 mm in size was scanned for seeds, which were removed and counted.

The heavy fractions from both sites contained numerous small pebbles, sherds, and lithic debris, in addition to animal bone fragments and carbonized plant remains—this diversity of materials made the process of sorting for plant and animal remains time consuming. I hired and trained undergraduate laboratory assistants at the University of North Carolina–Chapel Hill to assist with separating the animal bones and carbonized plants from the rest of the heavy fraction materials. Each heavy fraction was first sieved through a 0.7-mm geological sieve. Under my supervision, lab assistants sorted the plant and animal remains from the heavy fractions and bagged them separately. I scanned the residue (< 0.7 mm) for seeds. As with the light fractions, the carbonized plant remains from the heavy fractions were weighed and then sifted through 2.0-mm, 1.4-mm, and 0.7-mm standard geological sieves, and were sorted in entirety down to the 0.7-mm sieve size.

Modern botanical guides were used to determine what taxa might occur in the assemblages (Manríquez and Colin 1987; Soriano et al. 1997); the journal *Flora de Veracruz* was extremely helpful in this pursuit. Identifications were made with reference to modern comparative specimens housed in the paleoethnobotanical laboratory at the University of North Carolina–Chapel Hill. Most of the relevant comparative specimens were collected by the author during a trip to southern Veracruz, Mexico, in May 2000. In addition, several specimens were sent to Lee Newsom at Pennsylvania State University for identification. All plant specimens common in the assemblages were identified to the lowest possible taxonomic level. Taxonomic identification was not always possible—some plant specimens lacked diagnostic features altogether, while other specimens had diagnostic features but their taxonomic identifications were difficult to pin down. As a result, these specimens were classified as “unidentified” or “unidentified seed.” In other cases, probable identifi-

cations were made—for example, if a specimen closely resembled a maize cupule, but a clear taxonomic distinction was not possible (e.g., the specimen was highly fragmented), then the specimen was identified as a probable maize cupule and recorded as “maize cupule cf.”

Once the plant specimens were sorted and identified, I recorded counts, weights (in grams), portion of plants (e.g., maize kernels versus cupules), and provenience information. Wood was weighed but not counted, and no wood identification was conducted. Generally, most of the seeds identified in the samples were too small to weigh, and thus only counts were recorded. Larger palm seeds and avocado pits were identified only as fragments, and were both counted and weighed. Other than counts and weights, no measurements were taken on any specimens. Nearly all maize kernels were too fragmentary to obtain length or width measurements or to determine variety. Other than solitary maize cupules, no cob fragments were identified, thus prohibiting additional observations regarding variety.

Methods of Quantification

Quantitative methods in archaeobotany have developed significantly over the past several decades and, as a result, have been a subject of much critical discussion (Hastorf and Popper 1988). The most common methods for recording and quantifying plant remains are counts and weights. When deciding on basic measurements, it is important to choose those most appropriate to the taxa we intend to summarize. For example, I use counts as my basic measure because many of the specimens from my assemblages are too few and too small to yield appreciable weights. In terms of the data considered here, specimen weights would not be as useful an analytical measure as specimen counts.

Because of problems with comparability between different types of plant taxa, however, raw (or absolute) counts and weights are not appropriate comparative measures (Scarry 1986). For example, denser taxa yield higher weights than more fragile taxa, and some taxa yield higher seed counts than others (e.g., grasses vs. fruits) (Scarry 1986). Thus, using absolute counts or weights to summarize plant data is highly problematic. Most archaeobotanists agree that absolute counts are inadequate for assessing past people-plant interactions, in that they do not control for biases related to preservation and sampling error (Kandane 1988; Miller 1988; Popper 1988; Scarry 1986). Absolute counts and weights are simply

raw, unstandardized data—in order for them to be quantitatively useful, they must be standardized.

One way to avoid the problems of absolute counts/weights is through the use of ubiquity measures (Godwin 1956; Hubbard 1975, 1976, 1980; Popper 1988, Willcox 1974). Ubiquity measures are particularly useful for conducting spatial analyses to determine what types of taxa routinely find their way into specific depositional contexts. This type of analysis is essentially a presence/absence analysis that sidesteps the problems of counts and weights by measuring the frequency of occurrence instead of abundance. In other words, ubiquity analysis measures the number of samples in which a taxon was identified, as opposed to the number of specimens represented by that taxon. The researcher first records the presence of a specific taxon in each sample, and then computes the percentage of all samples in which the taxon is present (Popper 1988). For example, if avocado is present in 4 out of 10 samples, then its ubiquity value is 40%. Thus, each taxon is evaluated independently (Hubbard 1980). Because different types of plants are disposed of differently, direct comparisons of ubiquity values between taxa are problematic (Hubbard 1980: 53). For example, a 70% ubiquity value for hickory nutshell would not be equivalent to a 70% ubiquity value for beans, as these categories have different preservation opportunities—hickory nutshell represents a processing by-product often used as fuel, while beans represent edible portions. In my data analysis, I use ubiquity measures to evaluate the importance of specific taxa through time and to assess changes in the relative importance of these taxa through rank-order comparisons.

As with any quantitative measure, ubiquity analysis has its disadvantages. A sufficient number of samples is necessary to provide meaningful results, as using too few samples creates a high likelihood of sampling error. Hubbard (1976:60) suggests a minimum of 10 samples. Moreover, although ubiquity analysis may mitigate for preservation biases, it is not immune to them (Hubbard 1980:53; Scarry 1986:193). Most importantly, because ubiquity deals with occurrence frequency and not abundance, it can potentially obscure patterns where occurrence frequency does not change but abundance does (Scarry 1986). As Scarry (1986:193) notes: “[T]he frequency with which a resource is used may remain constant, while the quantity used varies.” For example, a family may consistently eat maize on a daily basis, but the quantity they consume may vary from day to day. Despite these weaknesses, ubiquity analysis is a good starting point and can provide meaningful results when used alongside other measures.

While ubiquity measures may sidestep the problems inherent in absolute counts, they do not provide a means for calculating relative abundances of different plant taxa. Using comparative ratios is one way of determining the relative abundances of different plants. Essentially, calculating a ratio is a means of standardizing raw measures. In other words, we can deal with the problems of absolute counts and weights by standardizing them in terms of some constant variable (Miller 1988; Scarry 1986). For example, if 100 maize fragments were identified at Site A and 27 maize fragments were identified at Site B, it would be problematic to conclude that people from Site A were cultivating, processing, or eating more maize than people from Site B (see also Table 4.1). The difference in maize counts might simply be a product of differences between the two sites in terms of (1) the sample size of each plant assemblage, (2) the volume of soil floated, or (3) the depositional contexts from which samples were taken. We must account for these variables if we want our relative abundances to be meaningful.

Generally, ratios can be divided into two categories: dependent ratios, such as percentages in which the numerator is a subset of the denominator, and independent or comparative ratios that involve two mutually exclusive variables (see Miller 1988). I focus my discussion on independent ratios. Independent or comparison ratios compare the relative amounts of two different items, the measures of which are categorically independent. Because both variables are independent of each other, the numerator and denominator need not be expressed as the same unit of measurement—for example, maize count/soil volume (also known as a density measure).

The density measure is perhaps the most commonly used independent ratio. This measure standardizes data in terms of soil volume—the absolute count or weight of carbonized plant material (for individual taxa or for larger collapsed categories, e.g., maize kernels or maize) is divided by total soil volume for each sample. Density measures calculate the abundance of plants per liter of soil, and it is generally assumed that larger volumes of soil will yield more plant remains. However, differences in the context and manner of deposition between soil samples structure the relationship between soil volume and the size of the plant assemblage. For example, a 10-L soil sample from an intact house floor would probably yield a smaller sample of carbonized plant remains than a 10-L soil sample from a refuse midden, because people tend to keep their houses cleaner than their trash dumps. Moreover, standardizing by soil volume does not control for the range of non-plant-related activities that contribute to the deposit from which the soil sample derives. In other words,

TABLE 4.1. SAMPLE COMPARISON OF PLANT WEIGHT AS A STANDARDIZER^a

	<i>Site A</i>	<i>Site B</i>
Raw maize counts	100	27
Total plant weight (grams)	121	36
Standardized maize counts (maize counts/plant weight)	0.83	0.75

^aComparison is based on one hypothetical sample for each site.

the density measure does not consider plant remains in terms of plant-related activities, but rather in terms of all of the activities that are represented in the deposit.

Thus, if the analyst is interested in determining the importance of a specific plant relative to the other plants in a sample or context, then density measures may be inadequate. Rather, standardizing by plant weight might be more appropriate (Scarry 1986). Unlike the density measure, standardizing by plant weight considers the contribution of a specific plant or category of plants solely in terms of plant-related activities. As a result, a plant weight ratio more accurately reflects spatial and temporal differences in plant use.

As a quantitative category, plant weight is a sum of weights recorded for all carbonized plant specimens per sample or context. Thus, for each sample, there is a total weight of plant material—this figure is the denominator used to standardize the variable of interest. For example, if we wanted to determine whether the relative contribution of maize with respect to the total plant diet differs between Site A (with 100 maize fragments) and Site B (with 27 maize fragments), then we would standardize maize counts to plant weight. Table 4.1 presents a comparison of maize counts standardized to plant weight for two hypothetical samples from different sites. If the sample from Site A yields a total plant weight of 121 g and the sample from Site B yields a total plant weight of 36 g, then the resulting standardized maize counts are 0.83 and 0.75, respectively. These values indicate that the overall plant diets of people at Site A and people at Site B were composed of comparable amounts of maize. This example, though simplistic, illustrates the fundamental differences between using raw counts and standardizing raw data by plant weight—if we had

based our interpretation on raw counts, then we would have erroneously concluded that people at Site A were eating more maize than people at Site B. (For the sake of simplicity, I base this example on a comparison of two samples—to arrive at this interpretation using a real data set, a larger number of samples would be needed.)

Independent ratios are also an excellent tool for determining how two variables vary relative to each other. As part of my analysis, I use maize kernel/cupule ratios to determine the extent of maize processing through time. Maize kernels represent the edible portion of the maize ear, and maize cupules represent the inedible by-products of processing maize to remove the kernels. By using a ratio to compare these different portions of the maize ear, it is possible to determine the intensity of maize processing in different areas of a site, as well as through time (Scarry and Steponaitis 1997).

Overall, ratios are useful quantitative tools that overcome some of the problems of absolute counts and provide more insightful results than ubiquity measures. Nevertheless, Scarry (1986:194) cautions that ratios can be difficult to interpret. A single ratio, in and of itself, is meaningless—it is only through comparison to other ratios that any single ratio achieves interpretive value (Scarry 1986). It is also important to understand that ratios reveal only the relative importance of plants within varied depositional contexts, not the absolute dietary contribution of actual resources used in the past (Scarry 1986).

Because ratios are calculated for individual samples and the study assemblages are composed of numerous samples, it is important to summarize the data in a way that produces meaningful results. Following Scarry (1986), I use box plots (see also Cleveland 1994; McGill et al. 1978; Scarry and Steponaitis 1997; Wilkinson et al. 1992). Box plots are graphical displays of actual data and thus use medians and dispersion around medians instead of means and standard deviations. One reason for using medians instead of means is that mean values may or may not represent actual values in the data, and the purpose of the box plot is to summarize a distribution of data, showing all the data values that compose the distribution. Moreover, using means and standard deviations is often inadequate for showing the variation in the data, as very different distributions can produce the same mean and standard deviation values (Cleveland 1994:215).

Box plots summarize distributions of data using several key features (Figure 4.1). The median or center value of the distribution is marked by the area of maximum constriction at the center of the box. The edges of

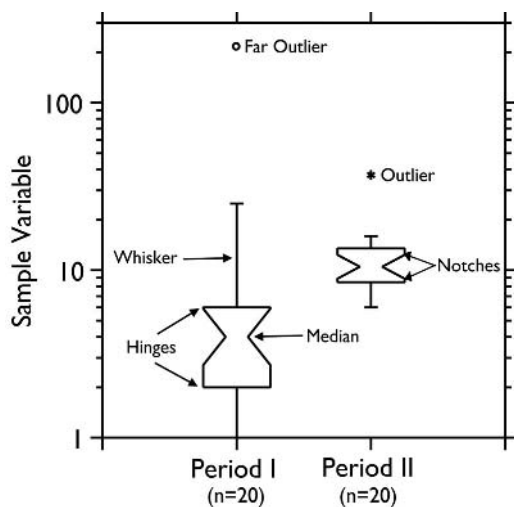


FIGURE 4.1. *Sample notched box plot.*

the box, or hinges, represent the 25th and 75th percentiles of the distribution—the approximate middle 50% of the data fall between the hinges (Cleveland 1994:139). Vertical lines, or whiskers, extend outward from the box and represent the tails of the distribution. Box plots also designate outliers—these are unusually large or small data values that “portray behavior in the extreme tails of the distribution” (Cleveland 1994:140). Outliers are depicted as asterisks and far outliers as open circles.

When comparing batches of data, and thus generating more than one box plot, it is possible to test for statistical differences between distributions. The box plot is easily modified by adding “notches,” which characterize the 95% confidence interval around the median. The notches are recognizable in that they give the box plot a characteristic hourglass shape. In some cases, a notch may extend beyond the hinge, appearing to fold back upon itself—this appearance does not change the interpretation of the graph (McGill et al. 1978:14; Scarry and Steponaitis 1997:113). If the notches of any two box plots do not overlap, then the medians of the two distributions are significantly different at about the 0.05 level (McGill et al. 1978:14; Scarry and Steponaitis 1997:113; Wilkinson et al. 1992:198). In addition, the plant data analyzed here and summarized in box plots are reexpressed as natural logarithms ($\ln[c/w]$, where c is the count of the taxon and w is the weight of plant remains in the same sample). Transforming the data in this way normalizes skewed distributions and thus facilitates the “visual and statistical recognition of patterns in the

data” (Scarry and Steponaitis 1997:114; see also Cleveland 1994:103–104; Velleman and Hoaglin 1981:48–55).

Diversity Analysis

Archaeobotanists and zooarchaeologists are often interested in determining the species diversity of their respective assemblages. A comparison of species diversity among different archaeological spatial or temporal units can have a great deal of interpretive value for assessing differences in procurement strategies, which can speak to issues of feasting, subsistence risk, and the changing composition of local flora and fauna, to name a few. For example, if artifactual evidence suggests a temporal shift in fishing strategies toward net-based procurement, a concomitant increase in the diversity of fish species would support and strengthen such an interpretation. Central to this analysis is the relationship between diversification and risk management (see Chapter 2). Because diversification of the food base is a key strategy for buffering against and responding to food shortages (Fenoaltea 1976; Guillet 1981; Walker and Jodha 1986), an increase in plant and/or animal diversity through time might indicate that people perceived new threats to the stability of their subsistence economy. Thus, by measuring diversity it is possible to identify fundamental changes in subsistence practices.

I consider two different measures of species diversity—richness and evenness. Richness refers to the number of taxa in a given assemblage—the more taxa present, the richer the assemblage (Kintigh 1984, 1989; Reitz and Wing 1999). Evenness, or equitability, refers to the uniformity of the distribution of taxa in the assemblage—if each taxon is represented by the same number of specimens or individuals, then they are distributed more evenly than an assemblage dominated by a specific taxon (Kintigh 1984, 1989; Reitz and Wing 1999).

While both diversity measures are broadly similar, neither deals explicitly with problems of sample size. It stands to reason that larger assemblages will yield a richer array of taxa than smaller assemblages (Baxter 2001; Jones et al. 1983; Kintigh 1989; Rhode 1988). Moreover, larger samples are more likely to yield rare taxa than smaller samples. Thus, it is problematic to assume that assemblages with more taxa have greater diversity than assemblages with fewer taxa without first ruling out whether differences in richness or evenness are structured by differences in sample size (Baxter 2001; Jones et al. 1983; Kintigh 1989; Rhode 1988).

In order to deal with issues of sample size with respect to measuring

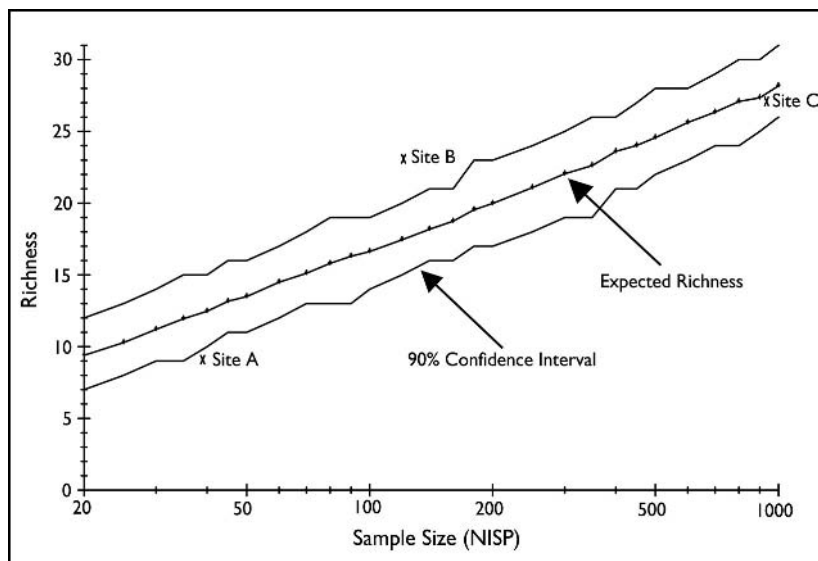


FIGURE 4.2. Sample DIVERS richness plot.

species diversity for my plant and animal assemblages, I use DIVERS, a statistical program designed to measure the diversity of assemblages of different sample sizes (Kintigh 1984, 1989, 1991). The DIVERS program simulates a large number of assemblages based on the categories and sample size of a given archaeological assemblage and produces expectations that can be compared with the actual data (Kintigh 1984, 1989). Thus, it is possible to judge whether the archaeological assemblage is more or less diverse than expected by comparing the richness and evenness of the actual assemblage to the expected values that are randomly generated by the simulation (Kintigh 1984, 1989). Archaeological assemblages, then, are not directly compared to each other. Rather, actual diversity values are compared with expected values for the same sample. For example, if one archaeological sample has 10 categories in a sample of 252 and another has 17 categories in a sample of 376, 10 is compared to the expected number of categories given a sample size of 252 and 17 is compared to the expected number of categories given a sample size of 376 (see also Kintigh 1984:45). The actual values are then plotted against sample size with a 90% confidence interval that is based on the expected values (Figure 4.2). If a value falls above the confidence interval, then it is more diverse than expected. Conversely, if a value falls below the confidence interval, then it is less diverse than expected.

THE STUDY ASSEMBLAGES IN ECOLOGICAL PERSPECTIVE

A variety of plant taxa were identified in the La Joya and Bezuapan flotation samples, including cultigens such as maize, beans, and avocados, as well as wild tree fruits, nuts, and several miscellaneous plants (Table 4.2). Overall, the Bezuapan flotation samples ($n = 105$) yielded a greater quan-

TABLE 4.2. COMMON AND TAXONOMIC NAMES OF PLANTS IDENTIFIED AT LA JOYA AND BEZUAPAN

<i>Common Name</i>	<i>Taxon</i>	<i>La Joya</i> (Presence)	<i>Bezuapan</i> (Presence)
FIELD CROPS			
Maize	<i>Zea mays</i>	X	X
Common bean cf.	<i>Phaseolus vulgaris</i> cf.		X
Scarlet runner bean	<i>Phaseolus coccineus</i>		X
Tepary bean cf.	<i>Phaseolus acutifolius</i> cf.	X	
Bean	<i>Phaseolus</i> sp.	X	X
Bean cf.	<i>Phaseolus</i> sp. cf.	X	
Bean family	Fabaceae	X	X
Bean family cf.	Fabaceae cf.	X	
TREE CROPS			
Avocado	<i>Persea americana</i>	X	X
Avocado cf.	<i>Persea americana</i> cf.	X	
Coyol	<i>Acrocomia mexicana</i>	X	X
Sapote	<i>Pouteria sapote</i>	X	X
OTHER FRUITS			
Prickly pear	<i>Opuntia</i> sp.		X
Guava	<i>Psidium guayava</i>		X
Grape family	Vitaceae		X
Sapote family	Sapotaceae		X
NUTS			
Acorn	<i>Quercus</i> sp.		X
Walnut family cf.	Juglandaceae cf.		X
MISCELLANEOUS			
Trianthema	<i>Trianthema</i> sp.	X	
Achiote cf.	<i>Bixa orellana</i> cf.	X	
Tres lomos	<i>Cupiana glabra</i>		X
Morning-glory family	Convolvulaceae		X
Probable tuber			X

tity of plant material representing a richer array of taxa than the samples from La Joya ($n = 318$). Plant remains from La Joya were generally sparse and highly fragmented.

Table 4.2 lists the common and taxonomic names of plants identified at La Joya and Bezuapan. I have grouped the plant remains into categories of field crops, tree crops, other fruits, nuts, and miscellaneous plants. Although more taxa were identified at Bezuapan than at La Joya, both sites share a common set of five major resources: maize, beans, avocado, coyol, and sapote. Below, I provide descriptions of the plants identified in these assemblages, focusing on these five resources. I include information about fruit size and yield, growing requirements, length of growing period, timing and methods of harvest, uses alternative to food, and potential cropping methods. It is important to note that these descriptions are drawn from modern observations of these plants. Nevertheless, this information can provide valuable insight into the manner in which these resources were managed and/or cultivated by Formative peoples.

Maize and beans are frequently discussed together, as they often represent partner crops. Whether or not they co-evolved as part and parcel of the same domestication process (see Chapter 2), maize and beans have a long tradition of intercropping and successional cropping in the New World (Lentz 2000). In general, maize requires good drainage and lots of moisture, and grows best between temperatures of 4°C and 47°C (Wallace and Bressman 1949:102, 215). Germination takes approximately 5–10 days (Kiesselbach 1999:14; Wallace and Bressman 1949:215). However, if temperatures fall below 13°C, germination can take up to 18–20 days; moreover, maize plants become susceptible to root rot at these low temperatures (Wallace and Bressman 1949:215). In tropical environments, seedlings appear in 2–3 days and duration of growth spans approximately 65 days under optimal soil temperatures of 26°C–30°C (Fischer and Palmer 1984:218).

Phaseolus beans are not tolerant of severe drought, although moderate drought has little affect on overall yields (Laing et al. 1984:303, 332). Seedlings emerge approximately 5–9 days from sowing at optimal soil temperatures of about 28°C (Laing et al. 1984:318). The average growing temperature required for *Phaseolus* beans is 21°C (Laing et al. 1984:306). Beans are not shade tolerant, and too much shade will reduce yields (Laing et al. 1984:327). Moreover, the longer the duration of growth, the greater the yield will be; this is also true of maize plants (Laing et al. 1984:324).

Intercropping beans with maize benefits bean growth, in that maize stalks support the climbing bean vines throughout plant growth (Smartt 1988:149). Moreover, intercropping also reduces the risk of pest and disease outbreaks (Smartt 1988:149). The primary importance of intercropping and successional cropping of maize and beans, however, lies in the ability of legumes to alter atmospheric nitrogen and make it available to the soil through chemical symbiosis with *Rhizobia* bacteria, a process known as N_2 -fixation (Giller 2001; see also Lentz 2000:93). This process contributes the most fixed nitrogen in farming (Giller 2001:17), and nitrogen is the best fertilizer for the maize plant (Wallace and Bressman 1949:92). *Rhizobia* bacteria form a symbiotic relationship with legume plants by infecting the nodules of their roots and stems (Giller 2001:18). During this symbiosis, the nitrogen from N_2 -fixation is assimilated by the legume plant (Giller 2001:65). Though legumes may remove more nitrogen from the soil than they contribute, they still have a better net loss of nitrogen than other crops (Giller 2001:71, 93). Thus, if legumes are intercropped with a cereal, they can improve the nitrogen economy of that crop (Giller 2001:93).¹

The common bean, however, is weak in N_2 -fixation relative to other leguminous plants (Laing et al. 1984:338). Two reasons for this are the quicker growth time of the common bean compared to other legumes (e.g., soybean) and the quicker growth time of plants in lowland versus highland settings (Laing et al. 1984:338). Shorter growth phases translate into less time for N_2 -fixation. Maize/bean intercrops mature much faster in lowland settings, and faster maturation equals lower yields (Laing et al. 1985:303; 324). Nevertheless, any N_2 -fixation is better than none.

In addition to enriching the growth and yield of maize plants, *Phaseolus* beans also complement maize in terms of nutritional value. Maize is deficient in essential amino acids lysine and isoleucine, which beans have in abundance (Bodwell 1987:264; Giller 2001:140). Thus, in addition to the benefits of cropping maize and beans together, there may also be benefits to eating maize and beans together.

The avocado (*Persea americana*) is an evergreen tree that originates in the highlands of central and east-central Mexico and the adjacent highlands of Guatemala (Nakasone and Paull 1998:76–77). On average, avocado trees require 1,250–1,750 mm of annual rainfall (Nakasone and Paull 1998:79). Although avocado trees need relatively dry conditions during flowering, excessive dryness can cause flowers and young fruit to drop prematurely (Nakasone and Paull 1998:79). Trees cannot tolerate

either water stress or excess moisture, but the Mexican cultivar seems to have greater tolerance to water stress and lower humidity than other varieties (Nakasone and Paull 1998:79, 93). Avocado trees are adaptable to a wide range of soils, including deep volcanic soils, sandy loams, and calcareous soils (CRFG 1996:2; Nakasone and Paull 1998:79). Good drainage is crucial for the root systems, because avocado trees are very susceptible to root rot (Morton 1987:97; Nakasone and Paull 1998:79). Average temperature requirements for avocado trees are 15°C–20°C at night and 20°C during the day, with humidity levels greater than 50% (Nakasone and Paull 1998:79–80). Avocado trees are easily damaged by winds and should be located in naturally sheltered areas (Nakasone and Paull 1998:79–80).

Avocado trees stand up to 15–18 m, with trunks 30–60 cm in diameter (Morton 1987:91; Nakasone and Paull 1998:81). They mature in 5–15 years, after which they begin producing fruit (Nakasone and Paull 1998:81). Trees produce 1–2 million flowers in a single bloom, though only 200–300 fruits will actually mature (Nakasone and Paull 1998:81–84). Flowering occurs from late spring through the fall and leads to water loss in the tree (CRFG 1996:2; Nakasone and Paull 1998:81–84). Fortunately, the latter part of this period corresponds to the rainy season in the Tuxtlas. Fruits mature 150–240 days after the trees bloom (CRFG 1996:4; Nakasone and Paull 1998:85–86). The fruit produced by an avocado tree is a single-seeded berry that is generally pear-shaped to oval and round (CRFG 1996:2; Nakasone and Paull 1998:85–86). Avocado fruits can weigh up to 227 g and yield 7.8%–40.7% oil content on a fresh weight basis (CRFG 1996:2; Nakasone and Paull 1998:85–86).

Of the fruit trees discussed here, avocados require the most intensive care. The location and spacing of avocado trees is critical for ensuring productive crops. Although avocado trees will grow in the shade and between buildings, they produce better yields if exposed to full sun (CRFG 1996:2; Woolf et al. 1999:143). Depending on the type of soil, trees should be spaced from 7.5–10.7 m apart (CRFG 1996:2; Morton 1987:97–98). Trees should not be touching (if trees touch one another, the branches tend to die back), but they should be close enough to facilitate cross-pollination (CRFG 1996:2; Morton 1987:97–98). Seedlings should be watered until the roots are established, and the ground around the tree requires close attention to weeding (Morton 1987:98). During the fruiting cycle, tree branches may need to be propped up due to the weight of the fruit (Morton 1987:98). Avocado trees must also be protected from rats and squirrels, as these rodents will devour the crop (CRFG 1996:3).

Avocado trees can yield from 20–100 kg of fruit per cycle, depending on the cultivar (Morton 1987:98). Most fruits will not fully ripen while still attached to the tree, as there is an inhibitor in the fruit stem (Morton 1987:98). For this reason, avocado fruits can be stored on the trees, although this can lead to biennial fruiting or crop failure the following year (Nakasone and Paull 1998:99). Some fruits, however, *will* change color and fall to the ground upon maturity (Nakasone and Paull 1998:99). It is important to be able to judge the maturity of the fruit, because not all fruits will fall from the tree, and those that do may be seriously bruised. Mature fruits are significantly higher in oil content and lower in moisture content than immature fruits (CRFG 1996:4; Nakasone and Paull 1998:99). They are best harvested by cutting or snapping off the stem near the base of the fruit (Nakasone and Paull 1998:99). Once mature fruits are picked, they will ripen in 1–2 weeks time (Morton 1987:98).

Formative people could have used the avocado for a variety of purposes, including food, food preservative, ink, clothing dye, and medicine. Avocado fruits are high in nutritional value, boasting the highest fiber content of any fruit. They are a source of antioxidants, and the oil is rich in vitamins A, B, C, and E and essential amino acids (Morton 1987:100; Nakasone and Paull 1998:99). Tannins are also present in the fruits, causing bitterness in the flesh when cooked (Morton 1987:100). Moreover, avocado leaves and unripe fruits may be toxic; dopamine and methyl chavicol are present in the leaves and have caused illness and fatalities when eaten by rabbits, and resins from the skin and the fruit have proven toxic to guinea pigs (Morton 1987:101). Roots and seeds from the plant, however, contain an antibiotic that prevents the spoilage of food by bacteria (Morton 1987:101). The seeds also yield a tannic fluid that can be used as ink (and was used in this manner on documents during the Spanish conquest) (Morton 1987:101–102). In Guatemala, bark from the avocado tree was boiled with dyes to help set color (Morton 1987:101–102). Avocado plants have also been used for a wide variety of medicinal purposes. Because of the antibiotic quality of the fruit skin, leaves, and seeds, these portions of the plant have been used to prepare treatments for dysentery, diarrhea, sore throats, hemorrhages, menstrual problems, dandruff, toothaches, and wounds (CRFG 1996:4; Morton 1987:102).

The coyol (*Acrocomia mexicana*) is a palm tree found throughout the American tropics that probably originated in southern Mexico (Henderson et al. 1995:166; McCurrach 1960:4; Quero 1992:31). Although the presence of coyol stands is usually associated with human activity, this species is not a true domesticate—its range was expanded by humans, but

it is capable of survival without human intervention (Greller 2000:74; Lentz 2000:108). It can grow up to 8 m in height, has a cylindrical trunk covered with spines 2–7 cm long, produces a globose fruit approximately 3–4 cm in diameter with a single seed, and is relatively hardy to cold conditions (Henderson et al. 1995:166; McCurrach 1960:4; Quero 1992:31). This palm tree is often found in disturbed areas such as secondary vegetation and agricultural fields, but is also well adapted to open savannas and open woodlands (Henderson et al. 1995:166; Quero 1992:31). In terms of cultivation, the seeds of the coyol are difficult to germinate, and when successful, germination takes about 4–6 months (McCurrach 1960:5).

Use of this palm has been documented for groups throughout Mexico and Central America (Lentz 1990). Coyol fruits are high in fat, protein, and caloric value (Lentz 1990:189). Formative people may have used the coyol for a variety of purposes, including food, medicine, and possibly wine production (Balick 1990; Greller 2000; Henderson et al. 1995; Lentz 1990; Quero 1992). The fruit itself is edible and is used to prepare sweet dishes (Quero 1992:32). Oil is extracted from the endosperm for use in cooking and hair tonics (Henderson et al. 1995:166). Medicinal uses include cooking the fruits for remedies for colic and diabetes (Quero 1992:32). Moreover, coyol tree trunks can be used in construction and palm fronds for thatching and weaving (Greller 2000:74). While it is the fruit of the coyol that is an ingredient in foods and medicines, wine is produced from the sap of felled trees (Balick 1990:86; Quero 1992:32). Fruits can be gathered and returned to camp for processing, but sap is gathered at the tree stands.

The mamey sapote tree (*Pouteria sapote*) can be found at low elevations in tropical environments from southern Mexico through northern Nicaragua (Morton 1987). It is most common from sea level up to 610 m, less common up to 910 m, and rare up to 1,220 m (Morton 1987:399). La Joya and Bezuapan are situated at about 200–300 m above sea level. Occasionally, sapote trees have been cultivated up to 1,500 m above sea level, but these trees tend to grow slowly and fruit maturity is significantly delayed. Sapote trees require moderate rainfall (1,780 mm annually), heavy soils with good drainage, and are intolerant of frost, drought, and excessively wet soil conditions (Balerdi et al. 1996:5; Morton 1987:399). The tree itself can grow up to 18 m tall (sometimes it can reach heights of 30–40 m) with trunks up to 1 m in diameter (Morton 1987:398). Sapote fruits are usually pear-shaped, but can also be round, ovoid, or elliptic; they are large and range from 7.5–22.8 cm in length and 22.7 g–2.3 kg in weight

(Balerdi et al. 1996:2; Morton 1987:398). The skin of the fruit is dark brown in color, leathery in texture, and approximately 1.5 mm thick. The flesh is colored salmon pink to red and is sweet and pumpkin-like in flavor (Balerdi et al. 1996:2). The fruit normally produces a single large seed (though it can yield up to four) that is hard, oily, and bitter (Balerdi et al. 1996:2; Morton 1987:398).

In terms of growth requirements, seeds must be planted very soon after removal from the fruit, and will germinate in 2–4 weeks time (Morton 1987:399–400). At this early stage, seeds are extremely vulnerable to loss by rodents. If propagated from seeds, sapote trees take 8–10 years to bear fruit (Balerdi et al. 1996:2; Morton 1987:399–400). When propagated vegetatively, however, trees will produce fruit in 1–4 years. Trees should be spaced 7.5–9 m apart, and though they don't require elaborate care, they will benefit from nitrogen-rich fertilizer (Morton 1987:400). Different cultivars bloom at different times during the year, allowing for year-round harvest of the fruit (Balerdi et al. 1996:2). Fruit maturation takes approximately 13–24 months (Balerdi et al. 1996:2). Mature trees produce 200–500 fruits annually, and large trees produce twice that (Balerdi et al. 1996:2). Sapote trees can survive for at least 100 years and bear copiously throughout their lives (Morton 1987:400).

In addition to the edible fruit (which today is generally eaten by hand), Formative people could have used the fruit's seeds in a variety of different ways. The seed can be boiled, roasted and mixed with cacao for making chocolate, or mixed with cornmeal, sugar, and cinnamon to make a drink called "pozol" (Balerdi et al. 1996:8; Morton 1987:401). The seeds also yield a white oily substance that has been used in foods, soaps/cosmetics, and to fix colors on painted gourds (Morton 1987:401). This seed oil also has a variety of medicinal uses, including as a skin ointment, hair dressing (for hair growth), eye/ear ointments, and a remedy for coronary problems (Morton 1987:401). In addition, the sapote may be slightly toxic; the leaves from the tree may be poisonous, and the sap is known to irritate the eyes and skin (Morton 1987:401).

Other fruits identified in the assemblages include prickly pear (*Opuntia* sp.) and guava (*Psidium guayava*). Prickly pear is a succulent that adapts well to high, dense forests that may be dry or very humid, and is often found in the southern neotropics, which include the study area (Oldfield 1997:17). This succulent produces a berry fruit that can be eaten raw or made into jams (Heywood 1993:65–67). Guava is adapted to both humid and dry climates, grows well in altitudes up to 1,200 m, and is often cultivated as a backyard plant (Morton 1987:359; Nakasone and Paull 1998:

150). Guava trees produce many-seeded berries from 3–10 cm in diameter (Nakasone and Paull 1998:157). Guava can be eaten raw or cooked; when eaten raw these fruits are often seeded and served sliced (Morton 1987:361; Sánchez-Vindas 1990:122).

Miscellaneous taxa identified at the study sites include trianthema (*Trianthema* sp.), achiote cf. (*Bixa orellana* cf.), and tres lomos (*Cupiana glabra*). *Trianthema* is an herb that grows well along the borders of secondary growth—it can either grow wild or can be cultivated in gardens (Rico-Gray 1979). In modern times, trianthema is sometimes used as fodder for pigs (Rico-Gray 1979:13), but it probably served as a seasoning in prehistoric times. Achiote is a shrub or tree that grows well in secondary vegetation and is sometimes grown in gardens (Coe and Diehl 1980b; Newsom 1993). Formative people may have used achiote seeds both as a food-coloring/dye and seasoning (Coe and Diehl 1980b:159; Heywood 1993:105–106; Newsom 1993; Newsom and Pearsall n.d.). Tres lomos is a tree that also grows well in secondary vegetation (Coe and Diehl 1980b:164). In modern times, wood from this tree has been used in house construction and the manufacture of tools (Coe and Diehl 1980b:164).

The archaeobotanical assemblages from La Joya and Bezuapan include a combination of wild and cultivated plants whose ecological requirements involve some form of anthropogenic intervention. Domesticates like maize, beans, and avocados are the most obvious examples. Other fruit trees, like sapote, coyol, guava, and prickly pear, were probably encouraged and managed by people as part of their kitchen gardens or perhaps even in orchards. Herbs like achiote and trianthema may have been grown in gardens as supplementary seasonings. These herbs thrive in areas disturbed by humans, so even if not intentionally grown in gardens, they may have existed in them. Tres lomos is an economically useful tree that also thrives in disturbed vegetation. The ecological information presented here indicates that Formative people actively modified their environment in order to focus on a few economically important resources.

BASIC RESULTS: THE STUDY ASSEMBLAGES IN TEMPORAL PERSPECTIVE

This section presents the results of the identification of the carbonized plant remains from the study sites, which form the basis for the quantitative analysis. The data are summarized by site and period (Tables 4.3, 4.4). Raw counts are provided for each taxon, and plant weight and wood weight are also provided. Also included is the number of samples assigned

to each period. Because some of the samples came from mixed contexts, I include only those that could be placed within a discrete chronological category.

La Joya

Most of the archaeobotanical samples from La Joya come from Early Formative, Terminal Formative, and Early Classic contexts. Middle and Late Formative contexts yielded fewer samples and, as a result, lower samples sizes in general (Table 4.3). The Early Formative and Early Classic samples yielded the greatest quantity of plant remains by weight, although the Early Classic assemblage is composed almost entirely of wood. A greater number of taxa were identified in the Early and Terminal Formative assemblages; these assemblages are also characterized by a greater overall abundance of taxa than the Middle Formative, Late Formative, and Early Classic assemblages. Despite the disparity in sample size and taxa representation between the different periods represented at La Joya, certain trends in the data are apparent. Maize (*Zea mays*) is ubiquitous throughout the site's occupation. Moreover, maize (*Zea mays*), beans (*Phaseolus* sp.), avocado (*Persea americana*), coyol (*Acrocomia mexicana*), and sapote (*Pouteria sapote*) appear to be the most common food resources at the site.

I have grouped maize and beans together as "field crops," though whether the beans were intercropped with maize in the fields is uncertain. While intercropping beans with maize would have provided benefits to both plants, beans may also have been grown in smaller garden plots located on the houselots. The Formative marks a period in the evolution of bean domestication, with the domesticated common bean (*Phaseolus vulgaris*) not appearing in Mesoamerica until the late Middle Formative period (see Chapter 2). Although a possible tepary bean (*Phaseolus acutifolius* cf.) was identified in the Early Formative period at La Joya and specimens assigned to the genus *Phaseolus* were identified in Early Formative, Terminal Formative, and Early Classic contexts, no common beans (*Phaseolus vulgaris*) were identified at the site.

Tree resources also appear to have contributed significantly to the Formative diet at La Joya. Seed fragments from avocado (*Persea americana*), coyol (*Acrocomia mexicana*), and sapote (*Pouteria sapote*) fruits were all identified at La Joya. Because no complete avocado seeds were recovered, it is difficult to assess whether the La Joya avocados were fully domesticated at this time. The frequency with which they were identified in the assem-

TABLE 4.3. COUNTS OF PLANT TAXA BY PERIOD^a FOR LA JOYA

	<i>EF</i>	<i>MF</i>	<i>LF</i>	<i>TF</i>	<i>EC</i>	<i>Totals</i>
Number of samples	158	13	30	65	52	318
Plant weight	7.23	0.56	0.62	3.56	11.3	23.27
Wood weight	6.57	0.26	0.42	1.59	10.99	19.83
FIELD CROPS						
Maize cupule	3			10	2	15
Maize kernel	91	5	6	153	10	265
Maize kernel cf.	4					4
Tepary bean cf.	1					1
Bean	6			22	1	29
Bean cf.	1			5		6
Bean family				1		1
Bean family cf.	5					5
TREE CROPS						
Avocado	8	3	4	10		25
Avocado cf.	5					5
Coyol	3	2		30	9	44
Sapote	1			22		23
MISCELLANEOUS						
Trianthema	1					1
Achiote cf.			1			1
UNIDENTIFIED PLANTS	182	74	23	311	26	616
UNIDENTIFIED SEED	7	3	2	3		15

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

blage, however, speaks to their importance as a food resource throughout the Formative sequence. Coyol palm fruits also appear to have contributed significantly to the Formative diet, and would have provided a major source of oil for cooking and other tasks. Sapote fruits appear to have been more important later in the sequence, during the Terminal Formative period. Indeed, only one sapote fragment was identified from the Early Formative assemblage. The lack of sapote remains from the Middle and Late Formative samples, however, is probably a reflection of sample size rather than actual usage.

Two other taxa identified in the La Joya plant assemblage include trianthema (*Trianthema* sp.) and a possible achiote specimen (*Bixa orellana* cf.). Both plants were probably used to season other foods.

Bezuapan

Although there were fewer flotation samples from Bezuapan than from La Joya, there was overall a greater abundance of plant remains at Bezuapan (Table 4.4). In addition to yielding higher specimen counts/weights and more taxa, the Bezuapan plant assemblage was also less fragmentary than the assemblage from La Joya. The first Terminal Formative (TF-I) occupation at Bezuapan yielded a much greater quantity of plant material than any other occupation at the site, probably because more samples were taken from TF-I contexts than from other occupations. Although the specimen counts and weights are much lower for the Late Formative, second Terminal Formative, and Classic occupations at Bezuapan, the total plant weight from each of these periods is still greater than that of any Formative occupation at La Joya.

As at La Joya, the most common plants are maize (*Zea mays*), beans (*Phaseolus* sp.), avocado (*Persea americana*), coyol (*Acrocomia mexicana*), and sapote (*Pouteria sapote*) (Table 4.4). In addition to several specimens assigned to the genus *Phaseolus*, scarlet runner bean (*Phaseolus coccineus*) and possibly common bean (*Phaseolus vulgaris* cf.) were identified in samples dating to the first Terminal Formative occupation. Avocado specimens were too fragmentary to assess whether or not they were domesticated, but given the occupations to which they date, it would not be surprising if the specimens were, in fact, domesticated. At any rate, Bezuapan's Late and Terminal Formative residents were probably growing and managing these tree resources.

Other fruits identified at Bezuapan include prickly pear (*Opuntia* sp.), guava (*Psidium guayava*), and specimens from the grape family (Vitaceae) and sapote family (Sapotaceae). A few fragments of nutshell were also identified at Bezuapan—two fragments of acorn (*Quercus* sp.) and one fragment tentatively identified to the walnut family (Juglandaceae cf.). These fragments come from samples dating to the first Terminal Formative occupation and probably do not represent significant food resources. Miscellaneous taxa identified in the Bezuapan assemblage include one specimen tentatively identified to the morning-glory family (Convolvulaceae), tres lomos (*Cupiana glabra*), and two probable tuber specimens.

TABLE 4.4. COUNTS OF PLANT TAXA BY PERIOD^a FOR BEZUAPAN

	<i>LF</i>	<i>TF-I</i>	<i>TF-II</i>	<i>CL</i>	<i>Totals</i>
Number of samples	19	49	23	14	105
Plant weight	7.66	106.64	11.58	14.21	140.09
Wood weight	5.7	92.33	10.37	7.91	116.31
FIELD CROPS					
Maize cupule	131	296	32	54	513
Maize cupule cf.		1			1
Maize kernel	46	184	16	31	277
Maize kernel cf.		1			1
Common bean cf.		3			3
Scarlet runner bean		3			3
Bean	15	24	4	3	46
Bean family	1	11	5	1	18
TREE CROPS					
Avocado	23	492	55	9	579
Coyol	142	396	48	805	1391
Sapote	10	130	2	14	156
OTHER FRUITS					
Prickly pear	1	1			2
Guava				1	1
Grape family				1	1
Sapote family		22			22
NUTS					
Acorn		2			2
Walnut family cf.		1			1
MISCELLANEOUS					
Morning-glory family cf.		1			1
Tres lomos			1		1
Probable tuber		2			2
Stem/peduncle		3		1	4
UNIDENTIFIED PLANTS	99	1179	184	211	1673
UNIDENTIFIED SEED		6	2	5	13

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

The inclusion of the tres lomos seed in the second Terminal Formative occupation probably reflects nonfood use.

QUANTITATIVE ANALYSIS: FORMATIVE PLANT USE THROUGH TIME

Because quantitative analysis depends in part on adequate sample size, I focus on the five resources most commonly identified at these sites—avocado, coyol, sapote, maize, and beans. Measures of species diversity, however, will consider all taxa identified. Samples sizes are generally small, especially for La Joya, so I restrict my analysis to temporal patterns. A spatial analysis of plant resources through time, though desirable, is simply not possible given the limited sample sizes.

Species Diversity

While the raw counts presented in Tables 4.3 and 4.4 document the range of taxa identified at the study sites, they do not offer much interpretative value in unstandardized form. Raw counts can, however, be used as a basis for measuring species richness and evenness. Because many of the taxa identified in the study assemblages represent plants that are either commonly cultivated in fields or gardens or that are secondary invaders, an increase in species diversity might reflect a combination of increasing sedentism, increasing field clearance for farming purposes, and the addition of new species to the field/garden repertoire. Thus, this measure has great potential for identifying changes in farming strategies.

La Joya. To examine diversity through time, I use Kintigh's (1984, 1989) DIVERS computer simulation. Figures 4.3 and 4.4 plot richness and evenness, respectively, by sample size for each period. The center line in the DIVERS plot represents the expected evenness or richness, and the lines around the center line represent the 90% confidence interval for expected values. Actual values are labeled.

In terms of richness, the Middle Formative, Late Formative, and Early Classic plant assemblages fall well within the expected range of values given their respective sample sizes. The Early Formative and Terminal Formative assemblages also fall within the expected range of richness values. These two assemblages differ from the others, however, in that their richness values fall along the edges of the expected ranges—the Early Formative sample at the upper limit of expected richness and the Terminal

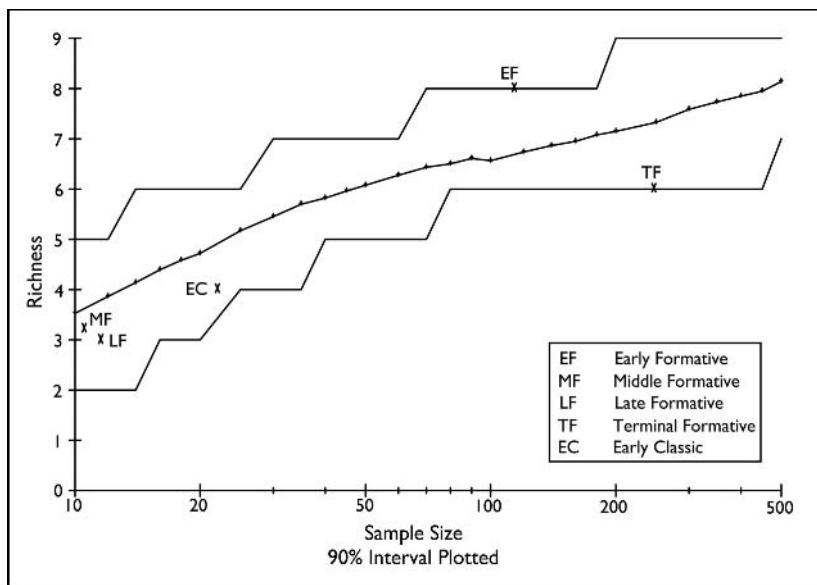


FIGURE 4.3. *DIVERS richness plot of La Jota plant remains by period.*

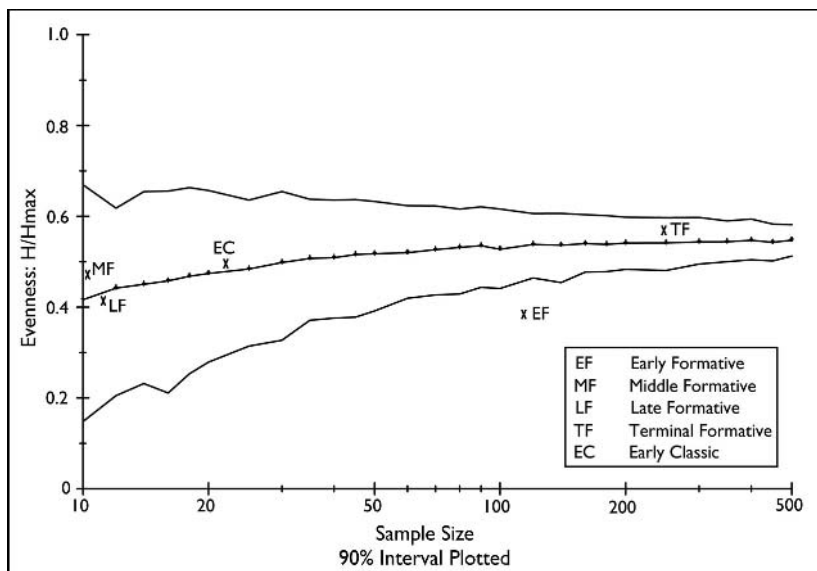


FIGURE 4.4. *DIVERS evenness plot of La Jota plant remains by period.*

Formative sample at the lower limit of expected richness. Thus, given the expected ranges of richness values for each assemblage sample size, it appears that the Terminal Formative plant assemblage is slightly less diverse than the Early Formative assemblage.

In terms of evenness, the Middle Formative, Late Formative, Terminal Formative, and Early Classic plant assemblages fall well within the expected range of values. The Early Formative sample, however, falls below the 90% confidence interval for the expected range of evenness values. In other words, the Early Formative plant assemblage is significantly less evenly distributed than expected given its sample size. Thus, it seems that the Early Formative plant assemblage was more heavily skewed toward maize than the later assemblages.

Overall, the DIVERS results suggest that people exploited the same set of plants throughout La Joya's sequence, although people may have slightly narrowed the range of species through time. In addition, it appears that Early Formative people at La Joya did not exploit their chosen plant resources to the same degree, instead focusing plant use around maize. The Middle, Late, and Terminal Formative and Early Classic residents of La Joya, however, appear to have exploited their plant resources in an equitable manner.

Bezuapan. The results of the DIVERS computer simulation for Bezuapan are presented in Figures 4.5 and 4.6. All three Formative occupations fall within the expected ranges of richness values given their sample sizes, although the Late Formative assemblage is at the low end of its expected range, suggesting a slight (but not significant) increase in species richness from the Late to Terminal Formative periods. Moreover, the Classic period sample falls below the 90% confidence interval of its expected range of richness values, indicating that it is less diverse than expected in terms of species richness.

In terms of evenness, both the Late Formative and second Terminal Formative assemblages fall within the range of expected evenness values. The first Terminal Formative and the Classic samples, however, fall outside the 90% confidence interval for expected evenness. Based on the DIVERS results, the TF-I assemblage is actually more evenly distributed than expected and the Classic assemblage less evenly distributed than expected, given their respective sample sizes.

Overall, it appears that the Terminal Formative plant assemblages may be slightly richer and more evenly distributed than the Late Formative

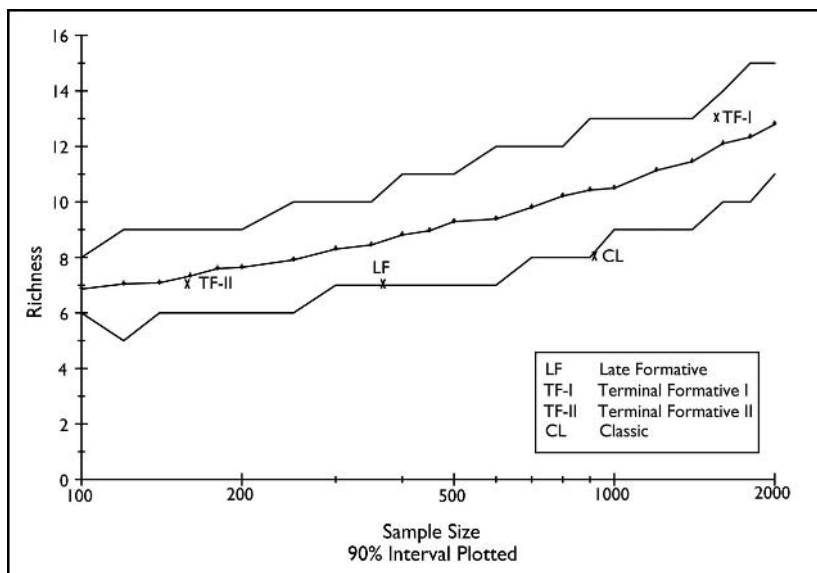


FIGURE 4.5. *DIVERS richness plot of Bezuapan plant remains by period.*

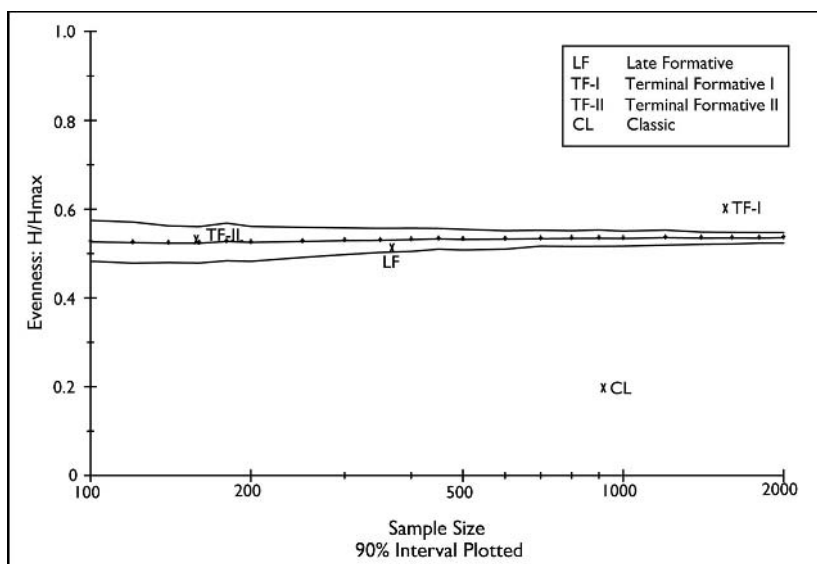


FIGURE 4.6. *DIVERS evenness plot of Bezuapan plant remains by period.*

and Classic period plant assemblages. In terms of richness, however, these apparent differences are not statistically significant.

Ubiquity Analysis

Ubiquity analysis is a presence/absence analysis that measures the occurrence frequency of a specific taxon in a given number of samples. I calculated ubiquity values for both sites by time period. I also ranked the resources in descending order by ubiquity values in order to get a sense of changes through time in the intensity of plant use.

La Joya. At La Joya, maize has the highest ubiquity value during all time periods (Table 4.5). Nevertheless, maize is only present in approximately 15%–30% of the samples during any given period. This low representation of maize and other plant resources at La Joya may be a product of poor preservation.

Because ubiquity deals with occurrence frequency and not abundance, the higher ubiquity values for maize relative to the other plant resources suggest that maize was being processed and prepared more regularly than the other plant resources—this is not surprising, given that maize requires more processing than beans or tree fruits. This more regular processing of maize may or may not relate to the relative abundance of maize in the diet of Formative peoples. In other words, just because maize required more processing than beans and tree fruits does not mean that it was more abundant as a dietary resource.

TABLE 4.5. UBIQUITY VALUES FOR PRIMARY PLANT FOOD RESOURCES AT LA JOYA THROUGH TIME

	<i>Samples</i> (<i>n</i>)	<i>Ubiquity</i>				
		<i>Avocado</i>	<i>Bean</i>	<i>Coyol</i>	<i>Maize</i>	<i>Sapote</i>
Early Classic	52	0	1.9	5.8	19.2	0
Terminal Formative	65	3.1	6.2	13.8	32.3	6.2
Late Formative	30	3.3	0	0	20	0
Middle Formative	13	7.7	0	7.7	15.4	0
Early Formative	158	2.5	2.5	1.9	29.1	0.6

TABLE 4.6. RANKING OF PRIMARY PLANT FOOD RESOURCES THROUGH TIME AT LA JOYA BY UBIQUITY VALUES^a

<i>Rank</i>	<i>EF</i>	<i>MF</i>	<i>LF</i>	<i>TF</i>	<i>EC</i>
1	Maize	Maize	Maize	Maize	Maize
2	Avocado/bean	Avocado/coyol	Avocado	Coyol	Coyol
3	Coyol			Bean/sapote	Bean
4	Sapote			Avocado	

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

TABLE 4.7. RANKING OF PRIMARY PLANT FOOD RESOURCES THROUGH TIME AT LA JOYA BY RELATIVE PERCENTAGES^a

<i>Rank</i>	<i>EF</i>	<i>MF</i>	<i>LF</i>	<i>TF</i>	<i>EC</i>
1	Maize	Maize	Maize	Maize	Maize
2	Avocado	Avocado	Avocado	Coyol	Coyol
3	Bean	Coyol		Bean/sapote	Bean
4	Coyol			Avocado	
5	Sapote				

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

To examine whether processing relates to consumption in this instance, I compared rankings of these resources by ubiquity values (Table 4.6) to rankings by relative abundance (Table 4.7). Relative abundance is a simple percentage of taxon counts relative to some total count, including that taxon. In this instance, relative abundance was calculated as taxon count (e.g., maize) divided by the sum of the counts for the five resources considered here. The rankings of these resources are identical for both measures, suggesting that frequency of use may reflect the relative abundance of resources in the diet of La Joya residents. Caution is warranted, however, as differing rates of fragmentation for different taxa make the interpretation of relative abundances difficult.

Changes through time in the rankings of other resources are also apparent. It is important to note that fewer samples come from Middle and Late Formative contexts than Early and Terminal Formative and Early Classic contexts, and any evaluation of temporal patterns must take this

into account. Coyol increases in frequency of occurrence and overall abundance after the Early Formative. Bean declines in frequency of occurrence and overall abundance sometime between the Early and Terminal Formative periods. Avocado slips in the ranking after the Late Formative period, and sapote is spotty throughout the sequence.

Bezuapan. At Bezuapan, maize has the highest ubiquity value during all periods except for the second Terminal Formative occupation (Table 4.8). At that time, avocado is slightly more ubiquitous, although the difference in ubiquity values for maize and avocado is negligible. Moreover, the drop in ubiquity values for all five resources after the first Terminal Formative period is puzzling and may simply reflect differences in the types of contexts from which flotation samples were collected. Alternatively, this dramatic change in ubiquity values during the Terminal Formative might indicate an overall decline in the processing, and by extension the consumption, of plant foods. This pattern of change during the Terminal Formative period at Bezuapan is not an isolated case and is not restricted to the plant data. Thus, I consider the broader implications of this pattern in Chapter 5, where I discuss the animal data.

As with La Joya, I also compare the rankings of ubiquity values with those of relative percentages for Bezuapan (Tables 4.9 and 4.10). With the exception of the switching of avocado and coyol during the first Terminal Formative period, these rankings are identical. Bean and sapote consistently rank low. Maize, coyol, and avocado consistently rank high, although avocado drops considerably in importance during the Classic period. These rankings are similar to those for La Joya, indicating relative stability through time in terms of the preference for certain plant foods over others.

TABLE 4.8. UBIQUITY VALUES FOR PRIMARY PLANT FOOD RESOURCES AT BEZUAPAN THROUGH TIME

	<i>Samples</i>	<i>Ubiquity</i>				
		<i>Avocado</i>	<i>Bean</i>	<i>Coyol</i>	<i>Maize</i>	<i>Sapote</i>
Classic	11	27.3	9.1	81.8	90.9	45.5
Terminal Formative II	23	55	8.7	30.4	52.2	8.7
Terminal Formative I	42	61.9	19	78.6	95.2	21.4
Late Formative	19	36.8	31.6	57.9	57.9	21.1

TABLE 4.9. RANKING OF PRIMARY PLANT FOOD RESOURCES THROUGH TIME AT BEZUAPAN BY UBIQUITY VALUES^a

<i>Rank</i>	<i>LF</i>	<i>TF-I</i>	<i>TF-II</i>	<i>CL</i>
1	Maize/coyol	Maize	Avocado	Maize
2	Avocado	Coyol	Maize	Coyol
3	Bean	Avocado	Coyol	Sapote
4	Sapote	Sapote	Bean/sapote	Avocado
5		Bean		Bean

^aLate Formative (LF), Terminal Formative I (TF-I), Terminal Formative II (TF-II), Classic (CL).

TABLE 4.10. RANKING OF PRIMARY PLANT FOOD RESOURCES THROUGH TIME AT BEZUAPAN BY RELATIVE PERCENTAGES^a

<i>Rank</i>	<i>LF</i>	<i>TF-I</i>	<i>TF-II</i>	<i>CL</i>
1	Maize	Maize	Avocado	Coyol
2	Coyol	Avocado	Maize/coyol	Maize
3	Avocado	Coyol	Bean	Sapote
4	Bean	Sapote	Sapote	Avocado
5	Sapote	Bean		Bean

^aLate Formative (LF), Terminal Formative I (TF-I), Terminal Formative II (TF-II), Classic (CL).

Independent Assessment of Taxa: Standardizing by Plant Weight

The rankings employed above provide a useful starting point for assessing variation between the different plant resources through time. The interpretation of the placement of any one resource, however, was dependent on the placement of the others. Here I consider each plant resource independently through the use of ratios. Ratios are useful quantitative tools that overcome the problems of absolute counts and provide better results than ubiquity measures. I standardize by plant weight (taxon counts/plant weight per sample) and present these values as distributions in the form of box plots. Sample sizes are presented at the bottom of each graph by period—sample size in the box plots refers to the number of samples in which the taxon was identified. The medians of two distribu-

tions are significantly different from each other at the 0.05 level if the notches in the box plots do *not* overlap (McGill et al. 1978:14; Scarry and Steponaitis 1997:113; Wilkinson et al. 1992:198).

La Joya. With the exception of maize, all of the plants identified at La Joya yielded very small sample sizes. Because bean, avocado, coyol, and sapote fragments were only identified in a few samples, presenting standardized counts of these plants in box plots has limited utility. Box plots are most effective when presenting distributions of multiple data values. Thus, I only consider standardized counts of maize at La Joya (Figure 4.7). Figure 4.7 reveals no significant differences in the distribution of maize through time. Although the distribution of maize during the Middle Formative appears to differ significantly from those during the Early and Late Formative periods, the Middle Formative distribution is represented by only two samples. Thus, the Middle Formative distribution can be disregarded on the basis of low sample size. Figure 4.7 illustrates that the contribution of maize relative to the overall plant assemblage remained relatively constant through time. Generally, it appears that the residents of La Joya processed and consumed comparable amounts of maize throughout the Formative and Early Classic periods.

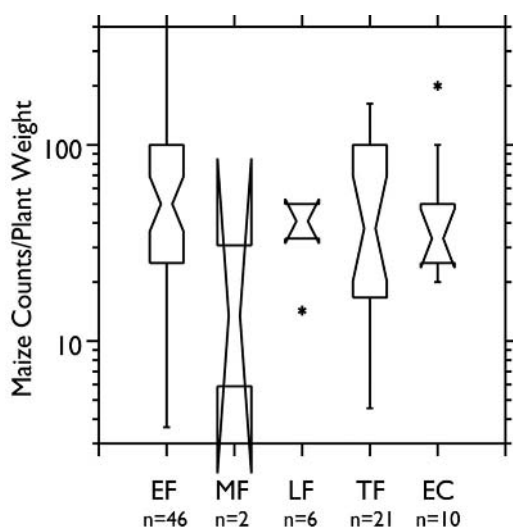


FIGURE 4.7. Box plot of standardized maize counts from La Joya by period (y-axis is log-transformed).

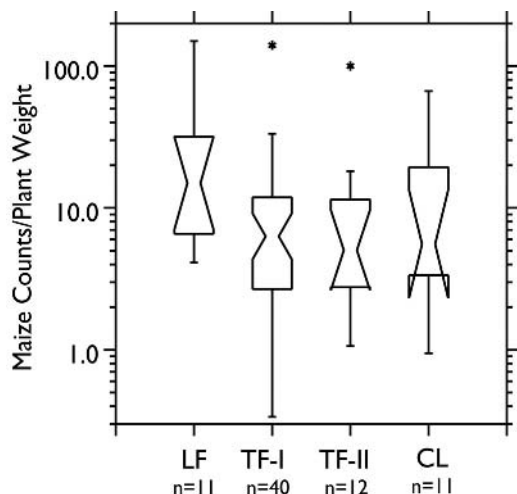


FIGURE 4.8. Box plot of standardized maize counts from Bezuapan by period (y-axis is log-transformed).

Bezuapan. At Bezuapan, sample sizes for maize, avocado, coyol, and sapote are much higher. Although the total count of beans is higher at Bezuapan than at La Joya, the beans from Bezuapan only come from a few samples. Thus, I do not consider standardized counts of beans from Bezuapan. Box plots of standardized values for maize reveal no significant differences through time (Figure 4.8). However, standardized maize counts are slightly higher (but not statistically significant) for the Late Formative period relative to the subsequent Terminal Formative period, which may indicate a decline in the contribution of maize to the Terminal Formative plant diet at Bezuapan.

The box plots presenting distributions of avocado and coyol remains show significant differences during the second Terminal Formative period (Figures 4.9 and 4.10). Specifically, the distribution of avocado remains is significantly higher during the second Terminal Formative period than during the Late Formative or subsequent Classic period (Figure 4.9). Moreover, the distribution of coyol remains is significantly higher during the second Terminal Formative occupation than the first Terminal Formative occupation (Figure 4.10). Further, the Classic period distribution of coyol is significantly higher than all previous occupations. Box plots of standardized values for sapote reveal no statistical differences through time (Figure 4.11).

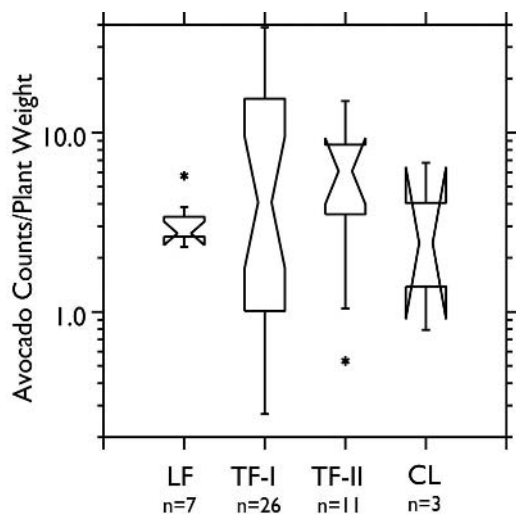


FIGURE 4.9. Box plot of standardized avocado counts from Bezuapan by period (y-axis is log-transformed).

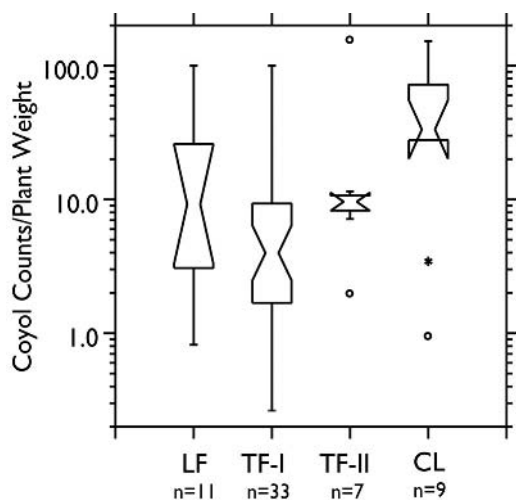


FIGURE 4.10. Box plot of standardized coyol counts from Bezuapan by period (y-axis is log-transformed).

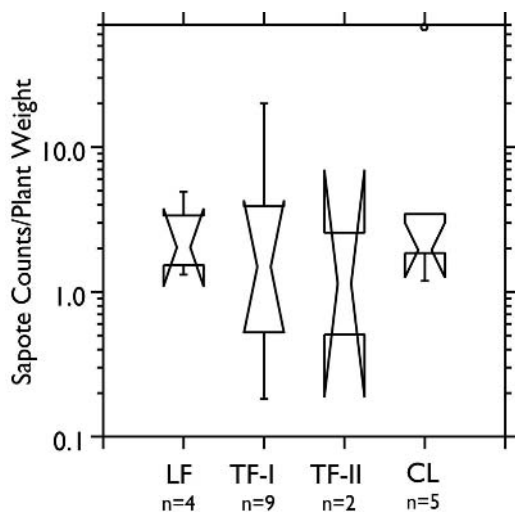


FIGURE 4.11. Box plot of standardized sapote counts for Bezuapan by period (y-axis is log-transformed).

These data indicate a possible decline in the production and consumption of maize during the Terminal Formative period, with a corresponding increase in the harvesting and consumption of avocado and coyol tree fruits during the Terminal Formative period. This change during the Terminal Formative parallels similar changes documented in the ubiquity analysis that I consider later in this chapter (see also Chapter 5).

Maize Processing: Kernel-to-cupule Ratios

Here I consider the archaeological residues of one of the initial stages of maize processing, that of shelling. Before maize can be ground into flour, the kernels must first be removed from the cob, leaving the cobs and cupules as byproducts of the removal process. Because kernels represent the part of the maize plant meant for consumption and cupules represent processing discard, lower ratios of kernel counts to cupule counts would be indicative of elevated levels of maize processing (Scarry and Steponaitis 1997: 117). For example, if we were to compare maize kernel-to-cupule ratios from different spatial locations or temporal periods, we could determine the relative degree of maize consumption versus processing across space and/or time.

Kernel-to-cupule ratios were calculated and expressed as dot charts (Figures 4.12 and 4.13) and in tabular format (Tables 4.11 and 4.12). The

TABLE 4.11. MAIZE KERNELS AND CUPULES
FROM LA JOYA

<i>Period</i>	<i>Maize Kernels</i>	<i>Maize Cupules</i>	<i>Kernel:Cupule Ratio</i>
Early Classic	10	2	5.0
Terminal Formative	153	10	15.3
Early Formative	91	3	30.3

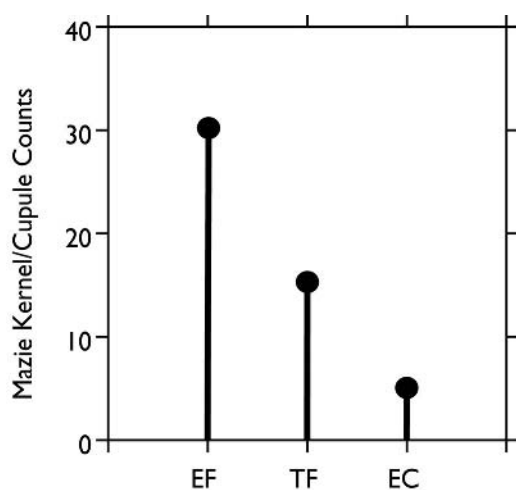


FIGURE 4.12. Dot chart of maize kernel-to-cupule ratios for La Joya by period.

Middle and Late Formative periods at La Joya were excluded from this calculation—sample sizes for these periods were low, and these contexts yielded no cupules, making the calculation impossible. The resulting dot chart shows a dramatic decrease in maize kernels versus cupules through time. This ratio decreases by a factor of 15 from the Early to Terminal Formative periods, and by a factor of 10 from the Terminal Formative to Early Classic periods, suggesting that La Joya residents increasingly processed more maize at the residential locus.

At Bezuapan, the maize kernel-to-cupule ratios are relatively low—in fact, lower than those from La Joya—and indicate that the residents of Bezuapan processed a lot of maize at the houselot. While the dot chart of these ratios shows an increase in kernel-to-cupule ratios through time, this change is miniscule (total increase is by a factor of 0.4) and probably

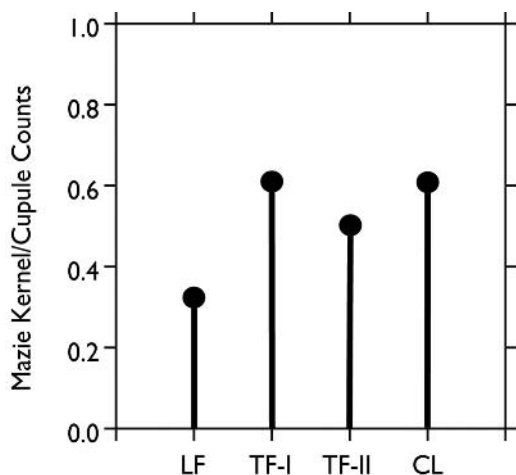


FIGURE 4.13. Dot chart of maize kernel-to-cupule ratios for Bezuapan by period.

TABLE 4.12. MAIZE KERNELS AND CUPULES FROM BEZUAPAN

<i>Period</i>	<i>Maize Kernels</i>	<i>Maize Cupules</i>	<i>Kernel:Cupule Ratio</i>
Classic	33	54	0.61
Terminal Formative-II	16	32	0.50
Terminal Formative-I	181	296	0.61
Late Formative	46	141	0.32

only represents micro-level changes in residential processing through time (Figure 4.14). Overall, the kernel-to-cupule ratios from Bezuapan are low and indicate that the residents of Bezuapan processed relatively equivalent amounts of maize throughout the site's occupation, which suggests a relatively consistent farming strategy during the Late and Terminal Formative periods. Indeed, the evidence for high levels of maize processing at Bezuapan may indicate a focus on infield production (see also Pool 1997).

What do these maize kernel-to-cupule ratios mean in terms of farming strategies? How do we explain the difference in kernel-to-cupule ratios through time at La Joya and between La Joya and Bezuapan? While we can assume that a decrease in kernel-to-cupule ratios indicates an in-

crease in the degree of maize processing, interpreting the cause(s) of this increase is more difficult. In other words, why do the data indicate that people were processing more maize through time at La Joya? Does this increase in processing mean that people intensified maize production through time? Perhaps. I propose three possible explanations for this decrease in kernel-to-cupule ratios at La Joya. The final explanation also attempts to account for the difference between the ratios at La Joya and Bezuapan.

First, it is interesting that this pattern of change from the Early to Terminal Formative period corresponds with the shift to sedentism at the end of the Early Formative period. Prior to the Early Formative, people were moving seasonally or annually throughout the region (Arnold 2000; McCormack 2002). Based on the botanical evidence, we now know that the Early Formative residents of La Joya were eating maize. Because the Early Formative settlement at La Joya was not a permanent settlement, it is possible that the maize recovered from Early Formative contexts was not produced in fields near the site. Rather, people may have grown maize in fields near other settlements they occupied during their seasonal rounds. If this were the case, then these Early Formative people probably would have shelled maize either in their maize fields or at their other settlements, transporting only that part of the maize plant meant for consumption (kernels) to La Joya in their seasonal or annual resettlement of the site. With the transition to year-round settlement at the end of the Early Formative, people would have begun producing and processing maize in fields located nearer the La Joya settlement, resulting in more maize-processing byproducts (cupules).

The second explanation relates to Killion's infield/outfield model of agricultural intensification presented in Chapter 3 (Killion 1987, 1990). As part of his model, Killion argues that the organization of residential space is closely correlated with the type of field-cropping strategy employed by the residents (Killion 1990:200). Killion was particularly concerned with whether infields or outfields were cultivated intensively. According to Killion's model, we can expect that people would have stored and processed maize at the houselot if infields were cultivated intensively. Conversely, if outfields were cultivated intensively, then we can expect that people would have stored and shelled their maize in the fields, away from the houselot. I argue that this would be the case even if fields were not being cultivated *intensively*. Whether people practice an intensive or extensive cultivation strategy, they still need to process their maize. As

Killion has demonstrated, where people choose to do so is dependent upon how close their fields are to the houselot.

Given this argument, the kernel-to-cupule pattern at La Joya might indicate that people changed their farming strategy through time to focus more on infield cultivation relative to outfield cultivation. One might argue that the shift toward the cultivation of more infields relative to outfields represents an intensification of maize production, in that people would have had to fallow land for shorter periods of time in order to maintain a focus on infield production. With shorter fallows, farmers would have had to invest more labor into their infield plots to produce sufficient yields—evidenced at La Joya and Bezuapan by field ridging during the Terminal Formative period (Arnold 2000; Pool 1997; Pool and Britt 2000).

These two explanations for increased maize processing at La Joya through time—the shift to sedentism and the increasing focus on infields—are not at odds with each other. They represent two complementary reasons behind this increase in maize processing at La Joya. It stands to reason that once people had permanently settled La Joya, they would have begun cultivating maize near the site, in infields. The field ridging identified at La Joya (and at Bezuapan) during the Terminal Formative period also indicates that people were intensifying their infield production during the Terminal Formative period (Arnold 2000; Pool 1997; Pool and Britt 2000).

But why did people at La Joya and Bezuapan intensify infield production? The kernel-to-cupule ratios from Bezuapan were comparable throughout the sequence, indicating continuity in farming strategies during the Late and Terminal Formative periods. It is interesting that intensive infield production at both Bezuapan and La Joya corresponds with regional political consolidation during the Late/Terminal Formative periods. It is possible that residents of La Joya and Bezuapan intensified maize production to produce enough maize to provide for themselves while funneling a portion of their yields to regional elites as tribute payments (see also Pool 1997). Moreover, the difference between the kernel-to-cupule ratios from La Joya and Bezuapan may represent the degree to which each settlement participated in this tribute network. The kernel-to-cupule ratios from Terminal Formative Bezuapan were much lower than those from Terminal Formative La Joya, suggesting that people were processing more maize at Bezuapan than at La Joya. Thus, if intensification is related to tribute in this case, then Bezuapan may have been more tightly integrated into the regional political economy than La Joya.

Tree Crops versus Field Crops

Thus far, I have focused on maize production at La Joya and Bezuapan, partly because low sample sizes of avocado, coyol, and sapote remains at La Joya made it impossible to compare standardized counts of these plants through time. Standardized counts of avocado and coyol from Bezuapan, however, indicated a significant increase in the use of these fruits from the Late through Terminal Formative periods. In addition, the ubiquity analysis of the Bezuapan data also revealed a possible pattern of increasing tree-fruit harvesting during the Terminal Formative period. To explore this pattern of increasing tree fruit exploitation, I aggregated data into categories of tree crops and field crops and constructed a ratio of tree crops to field crops for both La Joya and Bezuapan. This ratio is calculated as follows:

$$\frac{\Sigma \text{ counts of avocado, coyol, \& sapote}}{\Sigma \text{ counts of maize \& beans}}$$

Ratios are presented as dot charts for both La Joya and Bezuapan in Figures 4.14 and 4.15, respectively. Because sample sizes were so small for the Middle and Late Formative periods at La Joya, Figure 4.14 excludes these occupations, presenting values only for the Early and Terminal Formative and Early Classic periods. This graph clearly demonstrates an increase in the proportion of tree crops relative to field crops at La Joya through time. This does not necessarily indicate a declining importance of field crops through time. Rather, it appears that residents of La Joya were increasingly harvesting tree crops. The dot chart for Bezuapan reveals a similar pattern to that of La Joya (Figure 4.15). The ratio of tree crops to field crops clearly increases through time. Again, I stress that this does not mean that Formative people were cultivating or harvesting field crops less through time (although the box plot of standardized maize counts from Bezuapan did reveal a slight decrease in maize production after the Late Formative period).

Why the increase in tree resources through time? Avocado and sapote are known modern domesticates, and coyol, though not a true domesticate, has been managed by people for centuries. Most often when Mesoamerican scholars refer to agriculture, they are talking about field agriculture—specifically, maize and beans. Rarely have scholars considered the cultivation and management of tree crops as part of the prehistoric Mesoamerican agricultural system (but see Peters 2000; Gómez-Pompa 1987; McAnany 1995; Turner and Sanders 1992). However, if the data

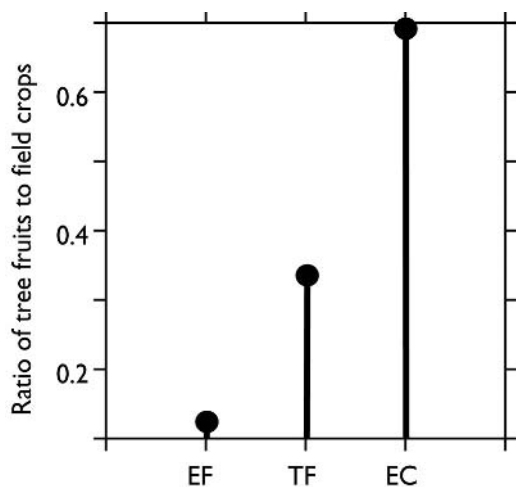


FIGURE 4.14. Dot chart of tree crop to field crop ratios (avocado, coyol, and sapote/maize and beans) for La Joya by period.

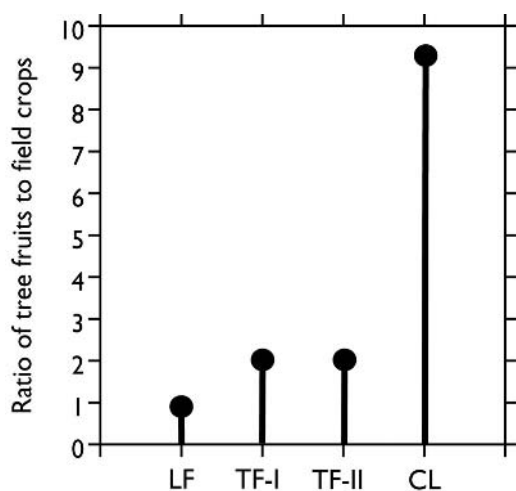


FIGURE 4.15. Dot chart of tree crop to field crop ratios (avocado, coyol, and sapote/maize and beans) for Bezuapan by period.

presented here suggest anything, it is that tree crop management and harvesting played an important role in the lives of tropical Formative peoples.

But why did the residents of La Joya and Bezuapan increasingly harvest and consume tree fruits? To answer this question, we need to understand the relationship between field cropping and tree management as

part of a swidden farming system. Swidden farming in the tropics can be considered an agroforestry system in that it produces useful plant resources, protects/enriches the soil, supports wildlife, and hastens the recovery of forest vegetation (Peters 2000:205). Arboricultural systems can in many ways be considered an outgrowth of the swidden farming system. Peters (2000) characterizes three related arboricultural systems that he terms the home garden, managed fallow, and managed forest.

The home garden is created through the planting of seeds and the transplanting of seedlings (Peters 2000:207). It is maintained through periodic weeding—this keeps the garden open, reduces competitors, and allows for easy access to plants—and is periodically fertilized by organic trash. Indeed, Lentz (2000:92) cites the use of human waste as fertilizer by the Aztecs and Maya. Once the home garden is abandoned, the larger trees may continue to grow and reproduce, and eventually be harvested by subsequent generations.

Managed fallow refers to agricultural fields that have been taken out of the cropping cycle, but the process of creating a managed fallow begins even earlier, when farmers clear a field from primary forest land (Peters 2000:209). At that time, people may spare economically useful trees (e.g., edible fruits trees), which then become part of the plot, usually located in the center or along the perimeter so as not to interfere with the primary field crop(s) (Lentz 1990:191; Peters 2000:209). After 1–2 years of cropping, the field reverts to fallow. In contrast to the home garden, the successional growth of secondary vegetation in managed fallows is not considered a weed problem (Peters 2000:208). Rather, many of these successional species become sources of food, construction material, and medicine (Lentz 2000:96; Peters 2000:208). Nevertheless, minimal weeding and fertilization may be conducted, and additional plants may be added or transplanted into the fallow field—these are usually shade-tolerant non-domesticates that can survive the competitive conditions (Peters 2000:210).

After 10–15 years, the field may be recleared and brought back under cultivation, at which time farmers will again spare economically useful trees—the cycle begun anew. Peters (2000:208) terms this cycle a monocyclic managed fallow. However, farmers may choose not to reclear the plot but rather to let it grow back into mature forest, or a polycyclic managed fallow (Peters 2000:208–209). People continue to maintain the plot and to harvest useful fruits, fibers, and medicinal plants (Lentz 2000:96; Peters 2000:209). Over time, the managed fallow is either cleared again or transformed into a managed forest orchard (Peters 2000:209). Once

the plot becomes a managed forest orchard, people continue to manage it through weeding, protecting desirable trees, selectively felling trees, and enrichment planting/transplanting.

The relevance of this system to tropical Formative swidden farming is readily apparent if one considers the cumulative effect of this anthropogenic process on the environment over a span of 1,000 years. During the Early Formative period, people were residually mobile, probably planting maize (and maybe beans) on a seasonal basis. At the end of the Middle Formative period, people were already sedentary and began to focus more on agricultural production (see also McCormack 2002). Over time, as populations increased and Formative people became more invested in the swidden cycle, they created more gardens, more managed fallows, and more managed forests. This process would have culminated in an increase in the proportion of edible fruit trees (and economically useful plant species as a whole) through time. Thus, by the end of the Formative sequence, people were literally harvesting the fruits of their labor to a greater degree, because the fruits were more readily available. The increase in tree crops relative to field crops, then, likely represents the culmination of a millennium of human-directed agroforestry that was a direct outcome of the swidden farming system.

RECONSTRUCTING THE FORMATIVE FARMING SYSTEM ON THE GROUND

How, then, did Formative people organize their agricultural system across the landscape? Given the data presented above and the growth requirements of the different plant resources used at the study sites, it is possible to construct a schematic of the Formative farming system (Figure 4.16; see also Killion 1987). The archaeobotanical data suggest that Formative people increasingly cultivated more infields relative to outfields through time. This shift in farming strategies may be indicative of increasing intensification. It is possible that this shift in agricultural strategies was facilitated by changes in the evolution of the bean (*Phaseolus* sp.). Tuxtla residents were cultivating beans by the Early Formative, and continued to do so for the next millennium. By the Terminal Formative period, people may have been cultivating common beans (*Phaseolus vulgaris*) (see above). Human-directed selection would have resulted in a shift from perennial vines to annual bushes (Gepts and Debouck 1991; Kaplan 1981; McClung de Tapia 1992; Smartt 1988; B. D. Smith 1998). These genetic changes would have enabled Formative farmers to shift the locus of bean produc-

tion from gardens to fields (see Chapter 2). The inter- and/or rotational cropping of maize and beans would have increased overall yields and soil fertility through N_2 -fixation (see above). While this process would not have enabled continuous cropping by any means, it may have allowed for slightly longer cropping periods, which, in turn, would have led to increased crop production on infields.

This shift in farming strategies associated with bean domestication may also have affected the location of avocado trees. As discussed above, avocado trees require full sun and need to be spaced approximately 10 m apart—close enough to cross-pollinate but far enough apart so as not to touch each other. They should not be located too close to structures, nor in forested areas. Of the three fruit trees considered, avocados require the most intensive care and must be protected from pests like rats and squirrels. They also benefit from nitrogen fertilizer. Given these requirements, I suggest that Formative people probably located their avocado trees along the perimeters of infield plots. Such a location would have ensured that they were close enough to the settlement for regular care, and that they were in a cleared area exposed to plenty of sunlight. Moreover, their location along the edge of maize/bean fields would have allowed them to benefit from the N_2 -fixation of the *Phaseolus* plants.

I imagine that sapote trees were a component of the home garden. They are sensitive to changes in moisture and would require close attention in terms of water conditions. Moreover, sapote seeds are vulnerable to loss by rodents during the early planting stage and would need protection from such pests. The archaeobotanical data indicate that sapote fruits were not as prevalent as avocados or coyols in the Formative diet, suggesting that Formative people may not have kept as many sapote trees as avocado trees. Indeed, a household may have only kept one or two sapote trees—or perhaps sapote trees were shared by several households. In any case, the archaeobotanical data, combined with the sapote's ecological requirements, argue strongly for a garden location.

Coyol trees were probably scattered across the landscape in agricultural fields, managed fallows, and managed forests. As discussed above, the coyol palm thrives in disturbed habitats and secondary growth. This palm is extremely hardy and does not require much care by humans. The coyol is an economically useful tree that was probably spared when Formative farmers cleared fields for cultivation. Formative people would have managed this resource in active infields and outfields, fallowed fields, and forests—they would not have needed to travel far to harvest these palm fruits.

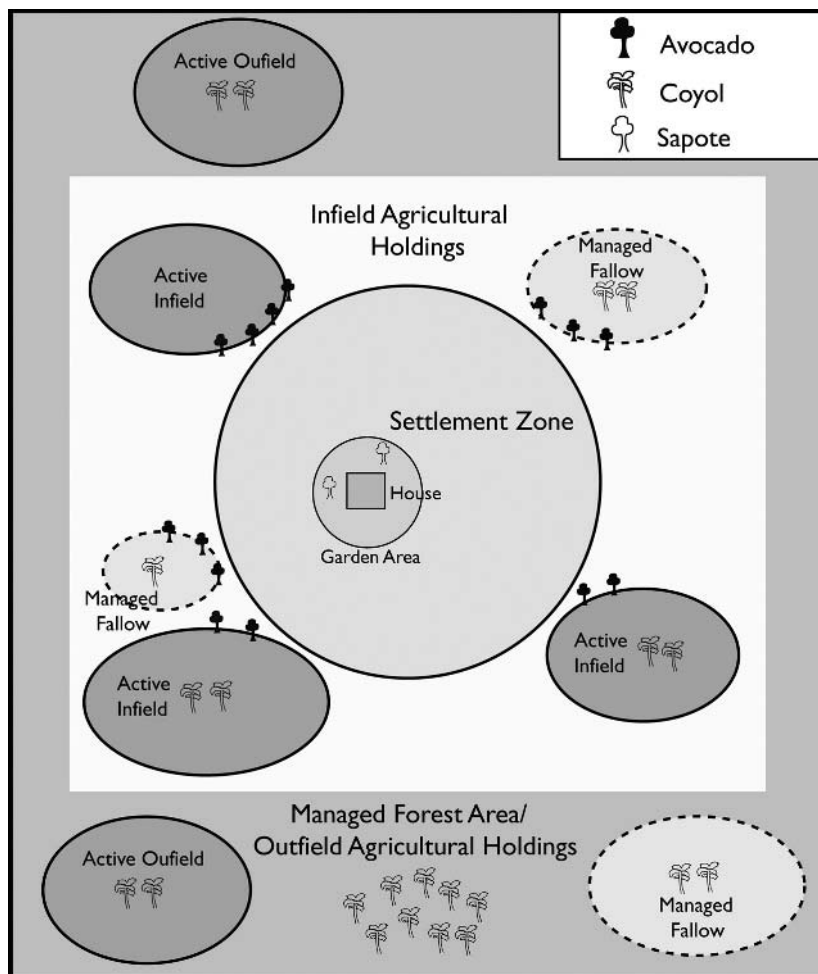


FIGURE 4.16. Schematic of agricultural/arboricultural holdings relative to residential space.

Other fruit-bearing plants such as guava and prickly pear may have been transplanted into gardens or maintained in managed fallows. Tres lomos, a tree economically important for its wood in house construction and toolmaking, was probably not actively managed in gardens, fallow fields, or forests, although its preference for disturbed habitats means it was probably a common invader in abandoned fields. Because this tree is used primarily for its wood and not its fruit, it was probably cut down when fields were recleared for agricultural purposes. Formative people

probably grew herbs like achiote and trianthema in their gardens or collected them wild from overgrown fallow fields.

This landscape—replete with household gardens, active infields and outfields cropped with maize and beans, managed fallows and forests with secondary growth, and fruit trees in abundance—would have attracted pests, resulting in an increased abundance of local fauna that are attracted to disturbed areas. The following chapter will further explore this relationship between farming and animal procurement.

SUMMARY AND DISCUSSION

Thus far, my discussion of farming, gardening, and tree management has focused on the organization of these activities on the ground and how this organization was structured by the relationship between people and the environment. Understanding the evolution of Formative agriculture, however, requires that we also consider larger regional political and environmental developments. Regional political consolidation and volcanic eruptions during the Late and Terminal Formative periods would have significantly impacted the choices people made with respect to plant food production and consumption. Here I summarize the archaeobotanical patterns and discuss them within the context of changes in regional political organization and response to volcanic eruption and ashfall.

The plant data from La Joya indicate a focus on maize by the Early Formative period. Although the kernel-to-cupule ratios show that Early Formative people were not producing or processing much maize at La Joya, the evenness results of the DIVERS computer simulation reveal that the diet of Early Formative La Joya residents may have been skewed toward maize. Nevertheless, the standardized maize counts reveal that people were not consuming more maize during the Early Formative than in subsequent periods. Because the Early Formative period at La Joya represents part of a larger, seasonally based settlement system, it is possible that people chose to settle at La Joya after the maize harvest, bringing an abundant supply of already shelled maize with them. Thus, what appears to be a focus on maize during the Early Formative may simply reflect a more seasonal subsistence strategy.

People stopped moving seasonally and settled permanently at La Joya by the end of the Early Formative. By the Terminal Formative period at La Joya, people had intensified maize production. The kernel-to-cupule ratios indicate that people were processing significantly more maize at the site by this time. This increased maize processing probably reflects both

the shift to settled life and the shift to infield production. People were also investing time and labor into ridging their fields by the Terminal Formative period. In addition to the intensification of maize production, people also began harvesting and consuming more tree fruits.

Bezuapan was settled during the Late Formative period, during a time of regional political consolidation. Maize kernel-to-cupule ratios indicate a high level of maize production and processing throughout the site's occupation. Nevertheless, standardized maize counts suggest a slight decline in maize consumption during the Terminal Formative period. At the same time, standardized counts of avocado and coyol increased. Thus, the possible decline in maize consumption corresponds with an increased consumption of tree fruits. This pattern is further bolstered by the ratios of tree crops to field crops and the increase in avocado ubiquity values during the Terminal Formative period.

Why did La Joya's and Bezuapan's Terminal Formative residents intensify maize production and increase their consumption of tree fruits? The shifts to settled life and infield production may explain the process by which people intensified maize production, but they do not explain why. And while the increasing availability of tree fruits is easily explained as a long-term consequence of the swidden system, people still had to choose to harvest and consume more tree fruits relative to field crops.

La Joya and Bezuapan were part of a hierarchical regional settlement system during the Late Formative period that included a political center at Chuniapan de Abajo. A volcanic eruption at the end of the Late Formative period led to massive regional depopulation, and the political capital was relocated to Chuniapan de Arriba (Santley et al. 1997). The initial intensification of maize production during the Late Formative period (as seen at Bezuapan) was probably tied to the rise of regional leaders who likely encouraged the mobilization of maize tribute from farmsteads and villages to political centers (see also Pool 1997). After volcanic eruption and ashfall at the end of the Late Formative period, maize production would have been more difficult (see Chapter 3), evidenced at Bezuapan by a slight drop in standardized maize counts during the Terminal Formative period. Volcanic eruption and ashfall would have destroyed maize crops and limited the short-term growth potential of new ones, but trees would have been less affected, rebounding more quickly. The residents of La Joya and Bezuapan assessed their situation and made up for the decline in maize production by harvesting more tree fruits.

Nevertheless, people continued to produce maize during the Terminal Formative period. However, based on the kernel-to-cupule ratios, the

residents of Bezuapan appear to have processed more maize than the residents of La Joya. Given the volcanic activity at this time, the significant drop in regional population, and the relocation of the regional political center, it is probably safe to assume that the political system was in disarray (see also Pool 2000; Santley et al. 1997, Stark 1997). Volcanic eruption and ashfall would have meant lower maize yields for the farmers that remained in the region. Lower maize yields and fewer overall farmers would have meant less maize tribute for regional elites. Within this context of political fragmentation, the difference in maize kernel-to-cupule ratios between La Joya and Bezuapan may indicate that the residents of La Joya provided less maize tribute to regional leaders than the residents of Bezuapan. Regional elites may have individually tailored their tribute demands for specific communities based on a volcanic damage assessment—perhaps farmland around La Joya was more negatively impacted by volcanic eruption and ashfall than farmland around Bezuapan, and thus residents of La Joya were not required to provide as much tribute. Alternatively, the power of regional elites may have become so fragmented that they could no longer evenly enforce their tribute demands throughout the region—perhaps the people at La Joya were able to ignore the demands of regional elites more easily than those at Bezuapan.

The following chapter further explores these issues through an examination of the animal data. Changes people make in their plant-based diet are often mirrored in their animal-based diet, and vice-versa. To fully understand how Formative people intensified maize production and dealt with the effects of volcanic impact within the context of regional political change, we must first understand how people integrated hunting and fishing with farming and fruit harvesting.

HUNTING, FISHING, AND TRAPPING: ANALYSIS OF THE ANIMAL DATA

The transition from a relatively mobile foraging economy to a sedentary farming economy involves fundamental changes in the way people interact with their environment. In the previous chapter, I discussed the ways in which Formative people manipulated the composition of their botanical world through swidden farming and tree management. These types of anthropogenic alteration of the local environment undoubtedly affected the distribution of local fauna as well. Moreover, as the livelihood of Formative people became more embedded in a farming economy, they probably altered the manner in which they exploited the faunal resources around them. Thus, the faunal record reflects local environmental changes as well as the choices people made with respect to animal procurement.

This chapter examines these issues through a quantitative analysis of the zooarchaeological data. I consider changes in both the natural landscape and the allocation of subsistence-based labor that accompany the shift to farming. Clearing fields for cultivation destroys primary forests and eliminates many floral and faunal habitats. At the same time, field clearance creates disturbance and edge habitats that are favored by other plants and animals. A close analysis of faunal patterns through time with an eye toward habitat preference allows us to link changes in hunting/trapping to changes in farming. After a discussion of methods (e.g., analysis, quantification),¹ I present an overview of the animals identified at the study sites and their habitat preferences. This is followed by a presentation of basic summary statistics (e.g., NISP, MNI) through time at both sites. I then review the garden-hunting model to set the stage for the quantitative analysis that follows. Next I present my quantitative analysis, beginning with a brief consideration of taphonomic issues and then moving on to explore changes in faunal exploitation through time. Finally, I discuss Formative strategies of animal procurement as they relate to changes in both the local environment and regional politics.

METHODS OF ANALYSIS

Recovery and Preservation Bias

The interpretation of zooarchaeological data depends upon the careful consideration of the potential taphonomic processes affecting bone assemblages. As with any archaeological assemblage, what is recovered and studied by archaeologists does not represent what was originally discarded and deposited by humans. It is important to be aware of the factors structuring bone assemblages, since all quantitative measures will be affected by taphonomic processes (Lyman 1994a:6–7). This section describes some of the taphonomic factors that affect bone assemblages. Methods for dealing with these issues will be addressed in the sections on laboratory procedures and quantitative methods.

Taphonomic issues in zooarchaeology have received considerable attention, especially in reference to interpreting skeletal part frequencies. This is largely because skeletal part frequencies are important for reconstructing patterns of animal butchery and carcass transport, as well as meat sharing/exchange within and between social groups (Bonnichsen and Sorg 1989; Guthrie 1967; Hudson 1993; Lyman 1987, 1994a; Metcalfe and Jones 1988; see also Binford 1978). Before social interpretations of differential carcass transport and/or food sharing can be invoked, differential bone survivorship must be ruled out. As with carbonized plant remains, whether or not a bone survives deposition and thus can be recovered archaeologically depends in part on its structural density (Binford and Bertram 1977; Brain 1969; Voorhies 1969; Lyman 1993; 1994a). Denser, compact bones with more cortical tissue are more likely to survive than are fragile bones with more cancellous tissue. Thus, long bone diaphyses will be more resilient than epiphyses, skull fragments more than vertebral fragments, large mammal bones more than small mammal bones, mammal bones more than bird bones, etc. Moreover, bone preservation in tropical environments tends to be relatively poor (Stahl 1995). High temperatures, a wet climate, and acidic soils create conditions resulting in highly fragmentary bone assemblages. Nevertheless, Stahl (1995: 155) argues that “quantitative and qualitative attributes of lowland archaeofaunal samples are not the sole result of diagenetic alteration.”

The structural density of bones determines bone survivorship in the face of carnivore or rodent ravaging, weathering, root etching, trampling, burning, and diagenesis, among other factors. Carnivores love to chew on bones, and if there were dogs on the site in the past, then it is certain

that the bone assemblage experienced some degree of carnivore ravaging. While carnivores sometimes leave characteristic tooth marks on bones indicative of gnawing, they often consume bones entirely, thus deleting them from the archaeological assemblage (Blumenschine 1988; Blumenschine and Marean 1993; Hudson 1993; Fisher 1995; Gifford 1981; Kent 1981; Lyman 1994a; Marean and Spencer 1991; Marean et al. 1992). Bone gnawing by rodents is also an issue. Because rodent incisors grow continuously, rodents need to gnaw on dense materials in order to wear their incisors down. This need to gnaw, coupled with the fact that many rodents burrow in the ground (e.g., gophers), often leads to rodent-ravaged bone assemblages, identified by characteristic rodent tooth marks (Fisher 1995; Gifford 1981; Lyman 1994a).

Another factor affecting bone survivorship is weathering. Behrensmeyer (1978:153) defines weathering as “the process by which the original microscopic organic and inorganic components of bone are separated from each other and destroyed by physical and chemical agents operating on the bone *in situ*, either on the surface or within the soil zone.” Essentially, weathering is a form of bone deterioration that is a cumulative process (Lyman 1994a:358–360). Throughout the weathering process, bone surfaces and matrices increasingly disintegrate, ultimately resulting in bones that crumble *in situ* (Gifford 1981; Behrensmeyer 1978; Lyman 1994a:354; Nicholson 1996). Root damage to bones simply speeds up this process. Whether root damage to bones occurs pre- or postburial, humic acid secreted either by plant roots or by the fungi associated with decomposing plants results in etching on the bone surface (Behrensmeyer 1978; Grayson 1988; Lyman 1994a; Morlan 1980; Nicholson 1996).

Trampling by humans and animals can also affect the composition of a bone assemblage, through movement of bones within the soil substrate, the creation of trampling marks on bones, and bone fragmentation (Gifford 1981; Lyman 1994a). Although some horizontal displacement of bones occurs through trampling, the vertical displacement of bones tends to be more typical (Gifford-Gonzalez et al. 1985; Olsen and Shipman 1988). Trampling also produces scratch marks on bones that are, unfortunately, microscopically similar to cut marks created by stone tools (Andrews and Cook 1985; Behrensmeyer et al. 1986, 1989; Fiorillo 1989; Lyman 1994a). Finally, trampling can also cause bone fragmentation. Determining whether bone fragmentation was caused by trampling rather than other factors such as carnivore gnawing, weathering, or cultural practices (e.g., intentional butchery, marrow processing, tool use), however, can be difficult. Nevertheless, determining relative fragmentation

rates for bone assemblages can provide a means for assessing the extent to which those assemblages were affected by taphonomic factors.

Laboratory Procedures

The zooarchaeological assemblages considered here come from screened and floated samples recovered from the sites of La Joya and Bezuapan. Because screened and floated bones were recovered using different techniques with different sampling strategies, they are reported and discussed separately. At La Joya, a total of 4,585 bone specimens weighing 2,920 g come from screened contexts; an additional 2,425 bone specimens weighing 62 g come from the 318 flotation samples that were selected for analysis. A total of 1,644 bone specimens weighing 1,836 g come from screened contexts at Bezuapan; an additional 4,489 bone specimens weighing 147 g were identified in the 108 flotation samples.

Screened bone specimens were sorted to the lowest possible taxonomic category. Specimens that could not be identified with reference to the zooarchaeological comparative collections at the University of North Carolina–Chapel Hill Research Laboratories of Archaeology were taken to the Zooarchaeology Collection at the Florida Museum of Natural History for comparison. Modern animal field guides were used to determine what taxa might occur in the assemblages, in addition to providing information on habitat preferences (Howell and Webb 1995; Lee 2000; Reid 1997; Soriano et al. 1997).

Identification of screened materials included recording of the provenience, animal class, genus and species, element, percentage and portion of the element represented, number of specimens, side of element (when applicable), observations regarding the age of the animal, bone modification (whether natural or cultural), and weight (grams). Each specimen was first assigned to the appropriate animal class whenever possible (e.g., mammals, birds, etc.). The anatomical element was recorded when identified. When the element could not be identified, it was placed in an unidentified category. Data collected regarding age included information on cranial fusion, long bone fusion, and tooth eruption, in addition to qualitative observations regarding bone porosity. Observations made with respect to bone modification included the presence or absence of burning and calcination, tool modification, discoloration not associated with burning, and cut marks.

All mammal specimens assigned to a medium- or large-size class were also observed for carnivore gnawing, rodent gnawing, root etching,

TABLE 5.1. WEATHERING STAGES FOR LARGE MAMMALS (BEHRENSMEYER 1978)

<i>Stage</i>	<i>Description</i>
0	No cracking or flaking on bone surface
1	Longitudinal and/or mosaic cracking present on surface
2	Longitudinal cracks, exfoliation on surface
3	Fibrous texture, extensive exfoliation, weathering penetrates 1–1.5 mm in bone surface, cracked edges are rounded
4	Coarsely fibrous texture, splinters of bone loose on the surface, open cracks
5	Bone crumbling <i>in situ</i> , large splinters

and evidence of weathering. Observations on carnivore gnawing, rodent gnawing, and root etching were recorded as present or absent. Observations on weathering were recorded as ordinal data based on Behrensmeyer's (1978) descriptions of weathering stages (Table 5.1; see also Lyman 1994a; Johnson 1985). Although Behrensmeyer's categories were designed for large mammals, I applied them to medium- to large-sized mammals as well, specifically to all mammals equal in size to or larger than the dog specimens identified in my assemblages.

Besides screened samples, faunal materials pulled from the heavy fraction components of the flotation samples were also analyzed. Identification of floated faunal materials involved the recording of provenience, animal class, number of specimens, and weight (grams). I believe that a class-based comparison between screened and floated faunal assemblages can speak to issues of potential size bias in field recovery techniques. For example, whether or not fish remains are underrepresented in the screened samples can be determined through a comparison with the floated samples. If the percentage of fish remains relative to the total floated faunal assemblage is significantly higher than the percentage of fish remains relative to the total screened faunal assemblage at a site, then we can be relatively certain that fish and other small animals are underrepresented in the screened assemblage.

Methods of Quantification

Quantitative methods in zooarchaeology have been the subject of much discussion and debate (Grayson 1973, 1979, 1981, 1984, 1989; Huelsbeck

1989; Lyman 1986, 1994b). Despite contention over the usefulness of basic measures, most zooarchaeologists calculate a standard set of summary measures that form the basis for further analysis. The most basic measure in zooarchaeology is the number of identified specimens (NISP). NISP is the count of identified specimens per animal taxon (Grayson 1984). For example, if the analyst identifies 71 bones or fragments of bones representing white-tailed deer, then the NISP for this animal equals 71. NISP can be quantified at different scales as well—there can be an NISP for white-tailed deer, for mammals, for a feature, or for a site.

While NISP is relatively easy to calculate, there are disadvantages to using it as an estimate for the relative abundance of different animal taxa in an assemblage. Different taxa vary in the number of elements that compose their skeletons, and NISP is unable to control for this (Grayson 1979, 1984; Reitz and Wing 1999). Another problem with NISP is that it does not account for differential preservation or bone fragmentation (Grayson 1984; Klein and Cruz-Uribe 1984; Reitz and Wing 1999). Clearly the bones of a white-tailed deer have more surface area than those of a cottontail and are thus likely to fragment into more pieces, significantly inflating the NISP of deer relative to cottontail. Thus, NISP may overestimate the contribution of larger animals relative to smaller animals.

To adjust for the problems of NISP in estimating the relative contribution of different animals to the diet, zooarchaeologists have developed alternative measures that are often used in addition to NISP. Perhaps the most widely used is the minimum number of individuals (MNI). MNI is a secondary measure based in part on NISP. MNI is estimated for each animal by calculating the occurrence of the most abundant element of the animal, while accounting for the side of the element (if applicable), portion represented, and relevant age information (Grayson 1984; Reitz and Wing 1999). For example, if the most abundant element of a white-tailed deer is the proximal end of a femur ($n = 12$), and eight come from the right side of the animal and four from the left site, the minimum number of white-tailed deer would be eight.

MNI has several advantages over NISP, the primary one being that it provides units that are independent of each other (Grayson 1973, 1984). While NISP does not account for the fact that different taxa are composed of varying numbers of skeletal elements, MNI is totally unaffected by this problem. Moreover, MNI is much less affected by the problems of fragmentation and preservation than NISP.

As with NISP, however, there are also disadvantages to using MNI, in-

cluding the inflation of rarer species in the assemblage and the problem of aggregation (Grayson 1984; Reitz and Wing 1999). NISP and MNI can best be understood as separate ends of a spectrum in which NISP represents the maximum number of individuals identified in an assemblage. NISP overestimates the importance of larger, more common taxa. At the other end of the spectrum, MNI (through setting a minimum) has the opposite effect and overestimates rarer taxa. Moreover, MNI calculations can vary based on how the analyst aggregates the data. There are many ways that the data can be grouped and MNI values calculated—by site, feature, feature type, stratigraphic level, etc. For example, calculating MNI on a feature-by-feature basis would yield a larger total MNI for each taxon than simply calculating MNI for the site as a whole. In my analysis, I calculate MNI for each site by period.

In order to qualitatively assess the interpretative value of relative animal dietary contributions (whether calculated through NISP or MNI), it is necessary to quantitatively assess taphonomic issues. I use several techniques to assess taphonomic bias in the screened assemblages. Since carnivore gnawing, rodent gnawing, and root etching were recorded as presence/absence data for all medium and large mammal specimens, I convert these data to percentages for the sake of comparison. These data are aggregated by time period for each site. For example, if 60 of 100 specimens (60%) were observed to have carnivore gnawing during the Early Formative occupation at La Joya versus 20 of 100 specimens (20%) during the Middle Formative occupation, then a decrease in the presence of this type of taphonomic agent would be quantitatively apparent. I did not set a minimum sample size threshold for deciding whether to include/exclude any given period—the smallest sample of specimens observed for taphonomic indicators is 63 and comes from the Late Formative occupation at Bezuapan.

I also consider the effects of weathering on the bones of medium and large mammals from the screened assemblages. Since information on weathering was recorded as ordinal data, I calculate the mean weathering stage for each site occupation. Finally, while a consideration of density-mediated attrition would add significantly to our understanding of the taphonomic history of the faunal assemblages, the sample sizes of white-tailed deer simply do not permit this type of analysis. As discussed above, bones with less structural density are more apt to be affected by mechanical and chemical attrition than bones with higher structural density. Testing whether density-mediated attrition has significantly biased the study assemblages would require a comparison of bone survivorship to known

volume density values for white-tailed deer (see Lyman 1994a: 234–258). Because the sample sizes of white-tailed deer specimens are too small to make this comparison, the taphonomic analysis conducted here is necessarily restricted to rudimentary measures of carnivore and rodent gnawing, root etching, and weathering.

THE STUDY ASSEMBLAGES IN ECOLOGICAL PERSPECTIVE

To understand how people scheduled their hunting, trapping, and fishing activities throughout the Formative period, we need to know which animals people were procuring and where they would have caught them. Did Formative people consistently exploit a wide variety of habitats, or did they focus on just one or two zones? Did people vary their hunting strategies through time to include more or fewer habitats? To examine these issues, I first present the list of species identified at the study sites (Table 5.2) and provide habitat information on the animals identified in the screened assemblages (see also Table 5.3).

A variety of animals were identified in the La Joya and Bezuapan screened assemblages, including fish, amphibians, reptiles, birds, and mammals (Table 5.2). Overall, the excavations at La Joya yielded a greater quantity of animal bone ($n = 4,585$) than the excavations at Bezuapan ($n = 1,644$), probably a result of differences in sampling—excavators at La Joya screened all soil, whereas excavators at Bezuapan screened only a sample of excavated soil (see Chapter 4). In addition to yielding more animal bones, La Joya is also represented by a richer array of taxa than Bezuapan, including more types of fish, reptiles, amphibians, and birds.

Table 5.2 lists the common and taxonomic names of the animals identified at La Joya and Bezuapan. Animals are listed in taxonomic order. Although more animals were identified at La Joya than at Bezuapan, the same overall set of taxa are represented in both assemblages, suggesting that the residents of both sites shared a similar hunting technology.

Specimens from both freshwater and marine fish are present in the assemblages. Freshwater fish include alligator gar (*Lepisosteus spatula*), mojarra (*Cichlasoma* sp.), and specimens from the sucker family (Catostomidae). Alligator gar prefer rivers and lagunas and are most abundant during the rainy season (Coe and Diehl 1980b: 118). Mojarra can be found in rivers and lakes throughout the region, including Lago Catemaco (Coe and Diehl 1980b: 118; Soriano et al. 1997: 447, 454). They prefer shallow water, swim along the bottoms of rivers and lakes, and are able to tolerate changes in salinity (Soriano et al. 1997: 447, 454). Catfish specimens from

TABLE 5.2. COMMON AND TAXONOMIC NAMES OF ANIMALS IDENTIFIED AT LA JOYA AND BEZUAPAN

<i>Common Name</i>	<i>Taxon</i>	<i>La Joya (Presence)</i>	<i>Bezuapan (Presence)</i>
FISH			
Alligator gar	<i>Lepisosteus spatula</i>	X	
Sucker family	Catostomidae	X	
Catfish family	Pimelodidae	X	
Snook	<i>Centropomus</i> sp.	X	X
Jack	<i>Caranx</i> sp.	X	
Snapper	<i>Lutjanus</i> sp.	X	X
Mojarra	<i>Cichlasoma</i> sp.	X	X
AMPHIBIANS			
Toad	<i>Bufo</i> sp.	X	X
Frog	<i>Rana</i> sp.	X	X
REPTILES			
Mexican giant musk turtle	<i>Staurotypus triporcatus</i>	X	X
Box/pond turtle family	Emydidae	X	X
Slider	<i>Trachemys scripta</i>	X	X
Green iguana	<i>Iguana iguana</i>	X	X
Boa constrictor	<i>Boa constrictor</i>	X	
BIRDS			
Duck family	Anatidae	X	
Muscovy duck	<i>Cairina moscbata</i>	X	X
Duck	<i>Anas</i> sp.	X	
Hawk	<i>Buteo</i> sp.	X	X
Falcon family	Falconidae	X	
Turkey/pheasant family	Phasianidae	X	
Wild turkey	<i>Meleagris gallopavo</i>	X	X
Northern bobwhite	<i>Colinus virginianus</i>	X	
Yellow-bellied sapsucker	<i>Sphyrapicus varius</i>	X	
Woodpecker family	Picidae		X
MAMMALS			
Opossum	<i>Didelphis</i> sp.	X	X
Nine-banded armadillo	<i>Dasypus novemcinctus</i>	X	X
Shrew family	Soricidae		X
Squirrel	<i>Sciurus</i> sp.	X	X
Hispid pocket gopher	<i>Orthogeomys hispidus</i>		X

(continued)

TABLE 5.2. (continued)

Common Name	Taxon	La Joya (Presence)	Bezuapan (Presence)
Mouse/rat family	Muridae	X	X
Coues' rice rat	<i>Oryzomys couesi</i>	X	X
Hispid cotton rat	<i>Sigmodon hispidus</i>	X	X
Mexican wood rat	<i>Neotoma mexicana</i>	X	X
Mouse	<i>Peromyscus</i> sp.	X	X
Rabbit	<i>Sylvilagus</i> sp.	X	X
Domestic dog	<i>Canis familiaris</i>	X	X
Skunk/weasel family	Mustelidae	X	
Northern raccoon	<i>Procyon lotor</i>		X
Ocelot	<i>Leopardus pardalis</i>	X	
Peccary family	Tayassuidae	X	
Collared peccary	<i>Tayassu tajacu</i>	X	X
Deer family	Cervidae	X	X
White-tailed deer	<i>Odocoileus virginianus</i>	X	X
Red brocket deer	<i>Mazama americana</i>	X	X

the Pimelodidae family were also identified in the study assemblages—some species in this family inhabit coastal waters, while others inhabit freshwater lakes and rivers, including Lago Catemaco (C. L. Smith 1997: 345; Soriano et al. 1997:452).

Marine fish include snook (*Centropomus* sp.), jack (*Caranx* sp.), and snapper (*Lutjanus* sp.). Snook are inshore fish that favor lagoons, estuaries, and the lower reaches of rivers (Coe and Diehl 1980b: 117; Hoese and Moore 1998: 190–191; C. L. Smith 1997:430). Jack are more variable in their habitat preferences; while most species favor open marine waters and offshore reefs, some prefer inshore waters and the lower reaches of estuaries (Hoese and Moore 1998: 221–222; C. L. Smith 1997:481–484). Snapper are also variable in their habitat preferences, and tend to inhabit shallow waters around reefs, sandy bottoms of bays and estuaries, and mangrove shores (Hoese and Moore 1998: 224; C. L. Smith 1997:494–499). All of these fish could have been procured from inshore and estuarine waters. Coastal waters are located about a day's walk (approximately 20 km) north of La Joya and Bezuapan. Fishing trips to coastal waters would have been overnight excursions at the very least, and would have

Hawk	X			X	X	X	X		
Wild turkey		X				X			
Northern bobwhite		X					X	X	
Yellow-bellied sapsucker	X			X	X			X	
MAMMALS									
Opossum		X						X	
Nine-banded armadillo		X		X	X		X		
Squirrel		X	X	X	X	X		X	
Hispid pocket gopher		X	X					X	
Coues' rice rat		X	X					X	X
Hispid cotton rat		X	X				X		
Mexican wood rat		X			X	X			
Mouse		X	X	X				X	
Rabbit		X	X	X	X			X	
Northern raccoon		X	X					X	X
Ocelot		X	X	X	X			X	
Collared peccary		X	X	X	X	X	X		
White-tailed deer		X	X	X			X		
Red brocket deer		X			X				

“Freshwater aquatic (FW); marine aquatic (MA); semi-aquatic (SA); arboreal (AR); terrestrial (TR); agricultural zones (AG); deciduous forests (DCF); evergreen forests (EGF); pine-oak forests (POF); open areas, savannas, grasslands (OSG); forest edge, secondary growth, weedy areas (FSW); mangrove/river/lake areas (MR).

taken some of the sites' residents away from the settlement for short periods of time. These excursions may have involved scheduling around the agricultural calendar.

Amphibians identified at La Joya and Bezuapan include toad (*Bufo* sp.) and frog (*Rana* sp.). The toad specimens could represent one of two species native to the Tuxtlas, cane toad (*Bufo marinus*) or Gulf Coast toad (*Bufo valliceps*) (Soriano et al. 1997: 509). Both species are common in disturbed habitats, often in close association with human habitations (Lee 2000: 85–89). It is unlikely that these toads would have been eaten, and they probably represent commensal taxa (e.g., household pests). The frog specimens probably represent Vaillant's frog (*Rana vaillanti*), as this is the most common frog native to the region. The lack of comparative specimens from this frog, however, made specific identification impossible. Vaillant's frog is terrestrial and nocturnal and prefers humid lowland forests (Lee 2000: 131). This species inhabits areas close to lakes and slow-moving rivers and streams (Lee 2000: 131).

Reptiles identified at the study sites include turtles, lizards, and snakes. Two turtles were identified, Mexican giant musk turtle (*Staurotypus triporcatus*) and slider (*Trachemys scripta*). Both turtles are aquatic and prefer lakes and marshes; the slider can also be found in rivers and streams (Lee 2000: 151, 161). People probably obtained these turtles from Lago Catemaco and possibly from Río Catemaco. Green iguana (*Iguana iguana*) is the only lizard represented in the two assemblages. Iguanas are relatively large arboreal creatures that are often found near lakes and rivers, where they perch on tree branches overhanging the water (Lee 2000: 194; Soriano et al. 1997: 486–488, 515). Iguanas were probably eaten; people could have easily captured them while fetching water or fishing along Río Catemaco or Lago Catemaco. Boa constrictor (*Boa constrictor*) was the only snake identified at the study sites; it is arboreal and nocturnal and can be found in savannas, primary forests, and occasionally secondary growth (Lee 2000: 260).

A variety of birds were identified at the study sites, including ducks, birds of prey, large terrestrial birds, and woodpeckers. Specimens from the duck family (Anatidae), including those identified to the genus *Anas*, could represent one of several species known to inhabit the region. Ducks within the genus *Anas* are generally small to medium-sized waterfowl that favor freshwater and estuaries (Howell and Webb 1995: 159); they were probably exploited near Río Catemaco or Lago Catemaco. One of the ducks common in the assemblages was muscovy (*Cairina moschata*), a perching duck commonly found near wooded lakes and rivers, as well as

near marshes. Terrestrial birds identified in the assemblages include turkey (*Meleagris gallopavo*) and bobwhite (*Colinus virginianus*), both of which prefer grassy fields and woodlands with thick understories (Howell and Webb 1995:225, 231). The procurement of these birds probably entailed hunting away from the residence. The hawk (*Buteo* sp.) could also represent one of several species found in the Tuxtlas, all of which prefer a variety of nonaquatic wooded and open habitats (Howell and Webb 1995:196–205). The yellow-bellied sapsucker (*Sphyrapicus varius*) is a migratory woodpecker that feeds on tree sap by drilling small holes in the mid to higher reaches of trees (Howell and Webb 1995:454). This bird can be found in forests and along forest edges, though rarely in pine forests (Howell and Webb 1995:454). The hawk and the sapsucker specimens probably do not represent food remains; these birds were most likely captured for their feathers.

Mammals represent the class from which residents of La Joya and Bezuapan exploited the widest range of taxa. Larger mammals identified in the assemblages include collared peccary (*Tayassu tajacu*), white-tailed deer (*Odocoileus virginianus*), and red brocket deer (*Mazama americana*). Both collared peccary and white-tailed deer inhabit a variety of habitats, including forests, forest edges, grasslands, disturbed areas, and occasionally agricultural fields (Coe and Diehl 1980b:102–103; Reid 1997:281, 283; Soriano et al. 1997:604–607). The red brocket deer is a small nocturnal deer that prefers undisturbed evergreen forests (Reid 1997:284; Soriano et al. 1997:606).

Medium-sized mammals include opossum (*Didelphis* sp.), hispid pocket gopher (*Orthogeomys hispidus*), nine-banded armadillo (*Dasyus novemcinctus*), rabbit (*Sylvilagus* sp.), northern raccoon (*Procyon lotor*), ocelot (*Leopardus pardalis*), and domestic dog (*Canis familiaris*). The opossum and gopher both prefer disturbed habitats, including areas along forest edges, secondary growth, and weedy areas (Reid 1997:43–44, 192). Today modern farmers in the region and Yucatec Maya farmers capture gophers through the use of snares (Coe and Diehl 1980b:106; Hovey and Rissolo 1999:261). Armadillos prefer deciduous and evergreen forests, thorn scrub, and savanna (Reid 1997:60). The rabbit could represent one of two species native to the Tuxtlas, eastern cottontail (*Sylvilagus floridanus*) and forest rabbit (*Sylvilagus brasiliensis*). Both species inhabit forest edges and areas of secondary growth, and the cottontail is known to be an agricultural pest (Reid 1997:250–251; Soriano et al. 1997:591–592). Raccoon was identified only in the Bezuapan assemblage, represented by a single specimen. Raccoons are widespread in coastal areas, are highly adapted to

disturbed habitats, such as towns and rural hamlets, and can be considered crop pests (Coe and Diehl 1980b:106; Reid 1997:258). The ocelot's range extends over a wide variety of habitats, including deciduous and evergreen forests, forest edges, areas of secondary growth, and agricultural areas (Reid 1997:270; Soriano et al. 1997:602–603). Domestic dogs probably lived on-site, where they scavenged for food and provided warning to the sites' inhabitants. The inclusion of dog remains in ordinary domestic refuse at both La Joya and Bezuapan suggests that dogs may have been a food resource as well.

Smaller mammals identified in the study assemblages include specimens from the shrew family (Soricidae), squirrel (*Sciurus* sp.), and specimens from the mouse/rat family (Muridae), including Coues' rice rat (*Oryzomys couesi*), hispid cotton rat (*Sigmodon hispidus*), Mexican wood rat (*Neotoma mexicana*), and mouse (*Peromyscus* sp.). The squirrel could represent one of two native species, the Mexican gray squirrel (*Sciurus aureogaster*) or Deppe's squirrel (*Sciurus deppei*), both of which prefer forests, forest edges, and secondary growth (Reid 1997:183–186). Deppe's squirrel is also a known agricultural pest (Reid 1997:186). Both the rice rat and the cotton rat favor disturbed habitats and agricultural areas (Reid 1997:203, 212; Soriano et al. 1997:593–594). The Mexican wood rat is relatively uncommon and tends to inhabit pine-oak forests and open woodlands (Reid 1997:219). The mouse specimens could represent one of two species native to the region, white-footed mouse (*Peromyscus leucopus*) and the Aztec mouse (*Peromyscus aztecus*); both favor forest edges, secondary growth, and weedy fields (Reid 1997:229–231). These mice and rats were probably agricultural and habitational pests; they likely represent commensal taxa, as opposed to food resources (but see Szuter 1994).

Overall, the animals represented in the vertebrate assemblages from La Joya and Bezuapan frequent a wide variety of habitats. Understanding local animal ecology is essential to understanding how people organized their hunting, fishing, and trapping activities. The quantitative analysis presented below incorporates information on animal habitats in order to explore how and why people altered the ways in which they procured animal protein.

BASIC RESULTS: THE STUDY ASSEMBLAGES IN TEMPORAL PERSPECTIVE

Before beginning the quantitative analysis, it is necessary to present the basic quantitative measures on which I will base my analysis. This section

presents the results of the taxonomic identifications of the screened and floated zooarchaeological assemblages by period. The data are summarized by NISP (number of identified specimens), MNI (minimum number of individuals), and bone weight.

La Joya: The Screened Samples

The screened zooarchaeological assemblage from La Joya consists of 4,585 bone fragments weighing 2,920 g. Because it was not possible to assign every specimen a discrete chronological designation, I consider only those specimens that each could be clearly identified with the Early, Middle, Late, or Terminal Formative, or Early Classic period.

The Early Formative Sample (EF). The faunal sample dating to the Early Formative period consists of 757 specimens representing 27 individuals (Tables 5.4, 5.5). Some 10.6% of this sample was unidentifiable. Of the specimens that could be identified to taxonomic class, fish contributed 10.9% by NISP, 14.8% by MNI, and 8% by weight (Tables 5.6–5.8). Both freshwater and marine fish were identified, including snook, jack, snapper, and mojarra.

Amphibians and reptiles from the Early Formative screened sample compose 2.5% of the NISP identifiable to class, 7.4% by MNI, and 2.2% by weight (Tables 5.6–5.8). Toad was the only amphibian identified to genus. Reptiles identified in the Early Formative include unidentified turtle remains and green iguana.

Birds represent 2.4% of the NISP identifiable to class, 18.5% by MNI, and 1.4% by weight (Tables 5.4–5.6). Several taxa were identified, including duck (*Anas* sp.), hawk, wild turkey, northern bobwhite, and yellow-bellied sapsucker. In addition, one specimen from the falcon family (Falconidae) was also identified.

Mammals contributed the majority of the NISP and MNI, representing 84.2% of the specimens identifiable to taxonomic class, 59.3% by MNI, and 88.3% by weight (Tables 5.4–5.6). The larger mammals identified in the Early Formative assemblage include collared peccary, white-tailed deer, and red brocket deer. Medium-sized mammals include opossum, hispid pocket gopher, rabbit, domestic dog, and ocelot. The inclusion of dog remains in ordinary domestic refuse during all time periods suggests that dogs probably were a food resource. Smaller mammals identified in Early Formative deposits at La Joya include squirrel and several species from the mouse/rat family (Muridae). Mice/rat species in-

TABLE 5.4. NISP (NUMBER OF IDENTIFIED SPECIMENS) FOR LA JOYA BY PERIOD^a

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
FISH										
Alligator gar							2	0.1		
Sucker family	1	0.1					1	0.0		
Catfish family							6	0.3		
Snook	7	0.9	3	1.3			33	1.5		
Jack	2	0.3					2	0.1		
Snapper	3	0.4	1	0.4			2	0.1	1	0.2
Mojarra	3	0.4			1	0.2	23	1.0	1	0.2
UID fish	57	7.5	20	8.4	8	1.5	389	17.7	8	1.5
AMPHIBIANS										
Toad	2	0.3	1	0.4	2	0.4	162	7.4	178	34.4
Frog									10	1.9
Toad/frog	2	0.3	1	0.4			33	1.5	50	9.7
REPTILES										
Mexican giant musk turtle							7	0.3	2	0.4
Pond/box turtle family					7	1.3				
Slider							49	2.2		
UID turtle	8	1.1			17	3.1	9	0.4	4	0.8
Green iguana		0.5					158	7.2	2	0.4

Boa constrictor						262	11.9		
UID snake	1	0.1			1	0.2	3	0.1	
BIRDS									
Duck family	1	0.1					1	0.0	
Muscovy duck							2	0.1	
Duck	2	0.3			1	0.2	1	0.0	
Hawk	1	0.1					1	0.0	
Falcon family	1	0.1			1	0.2			
Turkey/quail family			1	0.4					
Wild turkey	2	0.3			1	0.2			
Northern bobwhite	1	0.1					1	0.0	
Yellow-bellied sapsucker	1	0.1							
UID bird	7	0.9	1	0.4	1	0.2	16	0.7	1 0.2
MAMMALS									
Opossum	20	2.6			118	21.4	7	0.3	3 0.6
Nine-banded armadillo									4 0.2
Squirrel	1	0.1					2	0.1	
Hispid pocket gopher	30	4.0	7	2.9	9	1.6	8	0.4	
Mouse/rat family	2	0.3	2	0.8			13	0.6	5 1.0
Coues' rice rat	4	0.5	2	0.8			18	0.8	11 2.1
Hispid cotton rat	2	0.3			3	0.5	18	0.8	1 0.2
Mexican wood rat							2	0.1	
Mouse	8	1.1	7	2.9			72	3.3	7 1.4
Rabbit	10	1.3	2	0.8	2	0.4	10	0.5	2 0.4

(continued)

TABLE 5.4. (Continued)

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Domestic dog	5	0.7	6	2.5	11	2.0	51	2.3	6	1.2
Skunk/weasel family							1	0.0		
Ocelot	2	0.3								
Peccary family							1	0.0		
Collared peccary	2	0.3					1	0.0		
Deer family	8	1.1	16	6.7	7	1.3	11	0.5	1	0.2
White-tailed deer	8	1.1	10	4.2	20	3.6	36	1.6	14	2.7
Red brocket deer	1	0.1					1			
UID mammal	468	61.8	135	56.7	322	58.4	507	23.0	197	38.0
UNIDENTIFIED	80	10.6	23	9.7	19	3.4	275	12.5	14	2.7
TOTALS	757		238		551		2201		518	

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

TABLE 5.5. MNI (MINIMUM NUMBER OF INDIVIDUALS)
FOR LA JOYA BY PERIOD^a

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
FISH										
Alligator gar							1	1.7		
Snook	1	3.7	1	10.0			2	3.3		
Jack	1	3.7					1	1.7		
Snapper	1	3.7	1	10.0			1	1.7	1	4.2
Mojarra	1	3.7			1	7.1	4	6.7	1	4.2
AMPHIBIANS										
Toad	1	3.7	1	10.0	1	7.1	8	13.3	7	29.2
Frog									2	8.3
REPTILES										
Mexican giant musk turtle							1	1.7	1	4.2
Slider							1	1.7		
Green iguana	1	3.7					3	5.0	1	4.2
Boa constrictor							2	3.3		
BIRDS										
Muscovy duck							1	1.7		
Duck	1	3.7			1	7.1	1	1.7		
Hawk	1	3.7					1	1.7		
Wild turkey	1	3.7			1	7.1				
Northern bobwhite	1	3.7					1	1.7		
Yellow-bellied sapsucker	1	3.7								
MAMMALS										
Opossum	1	3.7					2	3.3	1	4.2
Nine-banded armadillo					2	14.3	1	1.7		
Squirrel	1	3.7					1	1.7		
Hispid pocket gopher	2	7.4	1	10.0	2	14.3	2	3.3	1	4.2
Coues' rice rat	2	7.4	1	10.0	1	7.1	6	10.0	3	12.5
Hispid cotton rat	1	3.7			1	7.1	2	3.3		
Mexican wood rat							1	1.7		

(continued)

TABLE 5.5. (*continued*)

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Mouse	2	7.4	2	20.0			11	18.3	3	12.5
Rabbit	1	3.7	1	10.0	1	7.1	1	1.7	1	4.2
Domestic dog	1	3.7	1	10.0	1	7.1	1	1.7	1	4.2
Ocelot	2	7.4								
Collared peccary	1	3.7					1	1.7		
White-tailed deer	1	3.7	1	10.0	2	14.3	2	3.3	1	4.2
Red brocket deer	1	3.7					1	1.7		
TOTALS	27		10		14		60		24	

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

clude Coues' rice rat, hispid cotton rat, and mouse. These mice and rats were probably agricultural and habitational pests; they likely represent commensal taxa, as opposed to food resources.

The Middle Formative Sample (MF). The faunal sample dating to the Middle Formative period consists of 238 specimens representing 10 individuals (Tables 5.4, 5.5). As with the plant data, the Middle Formative sample represents the smallest sample of all five periods. Some 9.7% of the sample was unidentifiable. Of the specimens identifiable to class, fish contributed 11.2% by NISP, 20% by MNI, and 4.9% by weight (Tables 5.6–5.8). Snook and snapper, both marine fish, were the only two fish species identified. Amphibians, reptiles, and birds were not well represented in the Middle Formative screened sample. Amphibians include one toad specimen and one specimen classified as toad/frog. There were no reptiles. Only two bird specimens were present, one unidentifiable beyond taxonomic class and one assigned to the turkey/quail family (Phasianidae).

Mammals were by far the most abundant taxonomic class, representing 86.9% of the NISP identifiable to class. The only large mammal identified was white-tailed deer. Domestic dog was also identified. The remaining mammals identified in the Middle Formative sample can all be classi-

fied as disturbance/edge taxa, and include hispid pocket gopher, Coues' rice rat, mouse, and rabbit.

The Late Formative Sample (LF). The Late Formative faunal sample consists of 551 specimens representing 14 individuals (Tables 5.4, 5.5). Only 3.4% of the sample was unidentifiable. Fish and amphibians were not well represented in the Late Formative sample, constituting 1.7% and 0.4% of

TABLE 5.6. NISP (NUMBER OF IDENTIFIED SPECIMENS)
SUMMARIZED BY CLASS AND PERIOD FOR LA JOYA^a

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Fish	73	10.9	24	11.2	9	1.7	458	23.8	10	2.0
Amphibians	4	0.6	2	0.9	2	0.4	195	10.1	238	47.2
Reptiles	13	1.9	0	0.0	25	4.7	488	25.3	8	1.6
Birds	16	2.4	2	0.9	4	0.8	22	1.1	1	0.2
Mammals	566	84.2	186	86.9	493	92.5	763	39.6	247	49.0
TOTALS	672		214		533		1926		504	

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

TABLE 5.7. MNI (MINIMUM NUMBER OF INDIVIDUALS)
SUMMARIZED BY CLASS AND PERIOD FOR LA JOYA^a

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Fish	4	14.8	2	20	1	7.1	9	15.0	2	8.3
Amphibians	1	3.7	1	10	1	7.1	8	13.3	9	37.5
Reptiles	1	3.7	0	0	0	0.0	7	11.7	2	8.3
Birds	5	18.5	0	0	2	14.3	4	6.7	0	0.0
Mammals	16	59.3	7	70	10	71.4	32	53.3	11	45.8
TOTALS	27		10		14		60		24	

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

TABLE 5.8. BONE WEIGHT (GRAMS) SUMMARIZED BY CLASS AND PERIOD FOR LA JOYA^a

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	<i>Wt. (g)</i>	<i>(%)</i>	<i>Wt. (g)</i>	<i>(%)</i>	<i>Wt. (g)</i>	<i>(%)</i>	<i>Wt. (g)</i>	<i>(%)</i>	<i>Wt. (g)</i>	<i>(%)</i>
Fish	35.05	8.0	9.18	4.9	2.43	0.5	93.15	8.9	3.54	1.9
Amphibians	0.63	0.1	0.24	0.1	0.17	0.0	21.66	2.1	36.68	19.7
Reptiles	9.37	2.1	0	0.0	12.56	2.5	154.6	14.7	5.2	2.8
Birds	6.06	1.4	1.22	0.7	5.66	1.1	10.82	1.0	0.02	0.0
Mammals	384.87	88.3	175.97	94.3	490.8	95.9	768.69	73.3	140.4	75.5
TOTALS	435.98		186.61		511.62		1048.9		185.84	

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

the NISP identifiable to class, respectively. Of these fish and amphibian remains, mojarra (a freshwater fish) and toad were identified. Reptiles compose 4.7% of the sample and include turtle remains from the slider family (Emydidae), unidentified turtle remains, and an unidentified snake specimen. Only 0.9% of the sample identifiable to class was represented by birds. These include duck (*Anas* sp.), wild turkey, and a specimen from the falcon family (Falconidae).

Mammals were the most abundant taxonomic class, representing 92.5% of the NISP identifiable to class, 71.4% by MNI, and 95.9% by weight (Tables 5.6–5.8). All of the wild mammals identified in the Late Formative sample are disturbance/edge fauna. White-tailed deer and opossum were the most abundant, followed by hispid pocket gopher, hispid cotton rat, and rabbit. Domestic dog is also present in the sample.

The Terminal Formative Sample (TF). The Terminal Formative faunal sample represents the largest sample at the site, totaling 2,201 specimens and 60 individuals (Tables 5.4, 5.5). Some 12.5% of this sample was unidentifiable. Of the specimens identifiable to class, fish represent 23.8% by NISP, 15% by MNI, and 8.9% by weight (Tables 5.6–5.8). Freshwater species include alligator gar, mojarra, and one specimen from the sucker family (Catostomidae). Marine species include snook, jack, and snapper—the same set identified in the Early Formative sample. Six catfish specimens from the Pimelodidae family were also identified.

Amphibians and reptiles compose 35.4% of the NISP identifiable to taxonomic class during the Terminal Formative period, a significant increase in their representation from previous periods (Table 5.6). Toad was the only amphibian identified, and is represented by 162 specimens and 8 individuals. Reptiles are represented by a diversity of species in the Terminal Formative sample. Two turtles were identified, the Mexican giant musk turtle and the slider. Green iguana and boa constrictor were also identified in the Terminal Formative sample.

Birds constitute only 1.1% of the NISP identifiable to class, 6.7% by MNI, and 1.0% by weight (Tables 5.6–5.8). Four species were identified, each represented by a single individual. These include muscovy duck, duck (*Anas* sp.), hawk, and northern bobwhite.

Mammals represent only 39.6% of the NISP identifiable to class and only 53.3% of the MNI, a significant decrease from earlier periods (Tables 5.6, 5.7). Large mammals include collared peccary, white-tailed deer, and red brocket deer. Medium-sized mammals represented in the sample are opossum, nine-banded armadillo, hispid pocket gopher, rabbit,

domestic dog, ocelot, and one specimen from the skunk/weasel family (Mustelidae). The armadillo was not identified in earlier samples from La Joya. Smaller mammals identified include squirrel, Coues' rice rat, hispid cotton rat, Mexican wood rat, and mouse.

The Early Classic Sample (EC). The faunal sample dating to the Early Classic period consists of 518 specimens representing 24 individuals (Tables 5.4, 5.5). Some 2.7% of this sample was unidentifiable. Fish represent only 2% of the NISP identifiable to class and include snapper and mojarra. Amphibians account for 47.6% of the NISP and 37.5% of the MNI, and are represented mostly by toads, in addition to several frog specimens (Tables 5.6, 5.7). Toads are represented by an NISP of 178 and an MNI of 9, a significant increase in this commensal species from previous periods. Reptiles identified in the Early Classic sample include Mexican giant musk turtle and green iguana. Birds are represented by a single specimen unidentified beyond taxonomic class. Mammals constitute only 45.8% of the NISP and 75.5% of the MNI, figures comparable to the Terminal Formative sample. Mammals identified include white-tailed deer, opossum, domestic dog, rabbit, Coues' rice rat, hispid cotton rat, and mouse.

La Joya: The Flotation Samples

Bone fragments from the heavy fraction of the flotation samples were identified to taxonomic class, counted, and weighed in order to assess size bias in recovery between screening and flotation methods. Table 5.9 presents NISP and % NISP of bone fragments from flotation samples by taxonomic class and period. The higher percentages of fish from flotation samples relative to screened samples during all periods indicate that fish are significantly underrepresented in the screened samples (see also Table 5.4). Nevertheless, a clear pattern emerges from the data. The percentage of fish remains from flotation samples clearly decreases through time, with a slight rebound during the Terminal Formative period. The significance of this pattern will be discussed later in the chapter.

Bezuapan: The Screened Samples

The zooarchaeological assemblage from screened contexts at Bezuapan consists of 1,644 bone fragments weighing 1,835.9 g. The species list from

TABLE 5.9. NISP (NUMBER OF IDENTIFIED SPECIMENS)
SUMMARIZED BY CLASS AND PERIOD FOR LA JOYA
FLOTATION SAMPLES

	<i>EF</i>		<i>MF</i>		<i>LF</i>		<i>TF</i>		<i>EC</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Fish	540	84.6	121	79.1	43	43.0	94	57.3	54	44.3
Amphibians	1	0.2	0	0.0	3	3.0	4	2.4	6	4.9
Reptiles	15	2.4	2	1.3	4	4.0	5	3.0	16	13.1
Birds	1	0.2	5	3.3	2	2.0	2	1.2	1	0.8
Mammals	81	12.7	25	16.3	48	48.0	59	36.0	45	36.9
TOTALS	638		153		100		164		122	

Bezuapan compares well with that from La Joya. As with La Joya, some specimens come from mixed contexts. Therefore, I consider only those specimens that could be placed within a discrete chronological category. Samples sizes are generally smaller for Bezuapan than La Joya.

The Late Formative Sample (LF). The Late Formative screened faunal sample from Bezuapan consists of 302 specimens representing 13 individuals (Tables 5.10, 5.11). Some 4.6% of the sample was unidentifiable. Fish represent 4.2% by NISP, 7.7% by MNI, and 1% by weight of the specimens identifiable to taxonomic class (Tables 5.12–5.14). Mojarra, a freshwater fish, was the only species identified. Amphibians and reptiles constitute 20.8% of the NISP identifiable to class, but account for only 2 individuals, a toad and a slider. Most of the reptile specimens were snakes that could not be identified to family or genus. Birds represent 4.5% of the NISP identifiable to class, 7.7% by MNI, and 5.5% by weight. The only bird identified in this sample was wild turkey.

Mammals dominate the screened assemblage from the Late Formative period, accounting for 70.5% of the NISP identifiable to class, 69.2% by MNI, and 83.3% by weight (Tables 5.12–5.14). Large mammals include white-tailed deer and red brocket deer. Medium-sized mammals include opossum, nine-banded armadillo, and domestic dog. Domestic dog remains were identified in all time periods, and their inclusion in ordinary domestic deposits suggests that they were eaten. Small mammals included in the assemblage are squirrel, hispid cotton rat, and Mexican wood rat.

TABLE 5.10. NISP (NUMBER OF IDENTIFIED SPECIMENS) FOR
BEZUAPAN BY PERIOD^a

	<i>LF</i>		<i>TF-I</i>		<i>TF-II</i>		<i>CL</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
FISH								
Snook							1	0.3
Snapper							3	1.0
Mojarra	1	0.3	1	0.3			3	1.0
UID fish	11	3.6	2	0.6	11	1.8	12	3.9
AMPHIBIANS								
Toad	1	0.3	23	6.8	86	13.7	90	29.6
Frog					7	1.1		
Toad/frog	1	0.3	6	1.8	11	1.8	7	2.3
REPTILES								
Mexican giant musk turtle			2	0.6	1	0.2	2	0.7
Pond/box turtle family					3	0.5		
Slider	8	2.6			15	2.4		
UID turtle	1	0.3			7	1.1	1	0.3
Green iguana					3	0.5		
UID snake	49	16.2	5	1.5	2	0.3		
UID reptile					9	1.4		
BIRDS								
Muscovy duck			2	0.6				
Hawk			1	0.3				
Wild turkey	5	1.7	4	1.2	2	0.3	7	2.3
Woodpecker family							1	0.3
UID bird	8	2.6	2	0.6			2	0.7
MAMMALS								
Opossum	10	3.3	4	1.2				
Nine-banded armadillo	40	13.2	3	0.9	21	3.3	13	4.3
Shrew family					1	0.2		
Squirrel	14	4.6	3	0.9	3	0.5		
Hispid pocket gopher					6	1.0	2	0.7
Mouse/rat family					2	0.3	4	1.3
Coues' rice rat					6	1.0	1	0.3
Hispid cotton rat	1	0.3			2	0.3		
Mexican wood rat	5	1.7			5	0.8		

(continued)

TABLE 5.10. (*continued*)

	<i>LF</i>		<i>TF-I</i>		<i>TF-II</i>		<i>CL</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Mouse					4	0.6	19	6.3
Rabbit			4	1.2	1	0.2		
Domestic dog	39	12.9	18	5.3	16	2.6	7	2.3
Northern raccoon			1	0.3	1	0.2		
Collared peccary			2	0.6				
Deer family							1	0.3
White-tailed deer	6	2.0	10	2.9	24	3.8	8	2.6
Red brocket deer	1	0.3	1	0.3	2	0.3		
UID mammal	87	28.8	227	66.8	352	56.1	84	27.6
UNIDENTIFIED	14	4.6	19	5.6	24	3.8	36	11.8
TOTALS	302		340		627		304	

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

The First Terminal Formative Sample (TF-I). The first Terminal Formative sample consists of 340 specimens representing 17 individuals (Tables 5.10, 5.11). Some 5.6% of the sample was completely unidentifiable. Fish represent only 0.9% of the specimens identifiable to taxonomic class, 6.3% by MNI, and 0.1% by weight (Tables 5.12–5.14). As with the Late Formative sample, mojarra was the only fish species identified. Amphibians and reptiles comprise 11.2% of the NISP identifiable to class, 17.7% by MNI, and 6.1% by weight. Toad was the only amphibian identified. Mexican giant musk turtle was the only reptile. Birds were slightly better represented, accounting for 3 individuals representing 3 different species: muscovy duck, hawk, and wild turkey.

Mammals account for 85% of the NISP identifiable to class, 58.8% by MNI, and 91.8% by weight. Large mammals in the assemblage include collared peccary, white-tailed deer, and red brocket deer. Medium-sized mammals include opossum, nine-banded armadillo, domestic dog, rabbit, and raccoon. Squirrel was the only small mammal identified in first Terminal Formative occupation. It is notable that no commensal rats or mice were identified.

TABLE 5.11. MNI (MINIMUM NUMBER OF INDIVIDUALS)
FOR BEZUAPAN BY PERIOD^a

	<i>LF</i>		<i>TF-I</i>		<i>TF-II</i>		<i>CL</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
FISH								
Snook							1	5.6
Snapper							1	5.6
Mojarra	1	7.7	1	5.9			2	11.1
AMPHIBIANS								
Toad	1	7.7	2	11.8	2	10.0	3	16.7
Frog					1	5.0		
REPTILES								
Mexican giant musk turtle			1	5.9	1	5.0	1	5.6
Slider	1	7.7			1	5.0		
Green iguana					1	5.0		
BIRDS								
Muscovy duck			1	5.9				
Hawk			1	5.9				
Wild turkey	1	7.7	1	5.9	1	5.0	1	5.6
MAMMALS								
Opossum	1	7.7	1	5.9				
Nine-banded armadillo	1	7.7	1	5.9	1	5.0	1	5.6
Squirrel	1	7.7	1	5.9	1	5.0		
Hispid pocket gopher					1	5.0	1	5.6
Coues' rice rat					2	10.0	1	5.6
Hispid cotton rat	1	7.7			1	5.0		
Mexican wood rat	1	7.7			1	5.0		
Mouse					1	5.0	4	22.2
Rabbit			1	5.9	1	5.0		
Domestic dog	2	15.4	1	5.9	1	5.0	1	5.6
Northern raccoon			1	5.9	1	5.0		
Collared peccary			1	5.9				
White-tailed deer	1	7.7	2	11.8	1	5.0	1	5.6
Red brocket deer	1	7.7	1	5.9	1	5.0		
TOTALS	13		17		20		18	

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

TABLE 5.12. NISP (NUMBER OF IDENTIFIED SPECIMENS) SUMMARIZED BY CLASS AND PERIOD FOR BEZUAPAN^a

	<i>LF</i>		<i>TF-I</i>		<i>TF-II</i>		<i>CL</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Fish	12	4.2	3	0.9	11	1.8	19	7.1
Amphibians	2	0.7	29	9.0	104	17.2	97	36.2
Reptiles	58	20.1	7	2.2	40	6.6	3	1.1
Birds	13	4.5	9	2.8	2	0.3	10	3.7
Mammals	203	70.5	273	85.0	446	74.0	139	51.9
TOTALS	288		321		603		268	

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

TABLE 5.13. MNI (MINIMUM NUMBER OF INDIVIDUALS) SUMMARIZED BY CLASS AND PERIOD FOR BEZUAPAN^a

	<i>LF</i>		<i>TF-I</i>		<i>TF-II</i>		<i>CL</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Fish	1	7.7	1	5.9	0	0.0	4	22.2
Amphibians	1	7.7	2	11.8	3	15.0	3	16.7
Reptiles	1	7.7	1	5.9	3	15.0	1	5.6
Birds	1	7.7	3	17.7	1	5.0	1	5.6
Mammals	9	69.2	10	58.8	13	65.0	9	50.0
TOTALS	13		16		20		18	

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

The Second Terminal Formative Sample (TF-II). The faunal assemblage from the second Terminal Formative occupation is the largest sample at the site, represented by 627 specimens and 20 individuals (Tables 5.10, 5.11). Only 3.8% of the sample was unidentifiable. Fish remains from this sample could not be identified beyond taxonomic class, and represent only 1.8% of the NISP identifiable to class. Amphibians and reptiles are abundant in this sample and are represented by a wider range of taxa than in

TABLE 5.14. BONE WEIGHT (GRAMS) SUMMARIZED BY CLASS AND PERIOD FOR BEZUAPAN^a

	<i>LF</i>		<i>TF-I</i>		<i>TF-II</i>		<i>CL</i>	
	<i>Wt.</i> (grams)	(%)	<i>Wt.</i> (grams)	(%)	<i>Wt.</i> (grams)	(%)	<i>Wt.</i> (grams)	(%)
Fish	3.13	1.0	0.72	0.1	1.23	0.2	17.38	6.7
Amphibians	6.38	2.0	8.55	1.7	15.69	2.5	18.7	7.2
Reptiles	27.19	8.4	21.42	4.4	56.62	9.1	7	2.7
Birds	17.78	5.5	9.47	1.9	8.76	1.4	22.92	8.9
Mammals	270.91	83.3	450.57	91.8	539.42	86.8	192.64	74.5
TOTALS	325.39		490.73		621.72		258.64	

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

previous periods at Bezuapan. Amphibians account for 17.2% of the NISP identifiable to class, 15% by MNI, and 2.5% by weight (Tables 5.12–5.14). Both toad and frog were identified. Reptiles identified in this sample include Mexican giant musk turtle, slider, three specimens from the slider family (*Emydidae*), and green iguana. Birds are not as well represented in the sample as reptiles, and wild turkey was the only species identified. Interestingly, wild turkey seems to be slightly more prevalent at Bezuapan than at La Joya.

Mammals dominate this assemblage, accounting for 74% of the NISP identifiable to class, 65% by MNI, and 86.8% by weight. White-tailed deer and red brocket deer were the only large mammals identified. Medium-sized mammals include opossum, nine-banded armadillo, hispid pocket gopher, rabbit, raccoon, and domestic dog. Small mammals include squirrel, Coues' rice rat, hispid cotton rat, Mexican wood rat, mouse, and a specimen from the shrew family (*Soricidae*). The shrew specimen identified in this sample represents the only one identified in the study assemblages.

The Classic Period Sample (CL). The Classic period screened assemblage consists of 304 specimens representing 18 individuals (Tables 5.10, 5.11). Some 11.8% of the sample was unidentifiable. Of the specimens identifiable to taxonomic class, fish represent 7.1% of the assemblage by NISP, 22.2% by MNI, and 6.7% by weight (Tables 5.12–5.14). More species of

fish were identified in the Classic period sample than in earlier samples from the site. They include both marine (snook and snapper) and freshwater (mojarra) species. Amphibians, primarily toad, account for as much as 36.2% of the NISP identifiable to class, and 16.7% by MNI. The only reptile identified in the sample was Mexican giant musk turtle, represented by two specimens. Birds were represented by wild turkey and a specimen from the woodpecker family (Picidae).

Mammals account for only 51.9% of the NISP identifiable to class, 50% by MNI, and 74.5% by weight (Tables 5.12–5.14). The only large mammal identified in this sample was white-tailed deer, which is ubiquitous through time and across both study sites. Medium-sized mammals identified include nine-banded armadillo, hispid pocket gopher, and domestic dog. Small mammals identified in the Classic period sample include Coues' rice rat and mouse.

Bezuapan: The Flotation Samples

Table 5.15 presents NISP and % NISP of bone fragments from flotation samples by taxonomic class and period. As with La Joya, the higher percentage of fish from flotation samples relative to screened samples during all time periods indicates that fish are significantly underrepresented in the screened samples (see also Table 5.12). Despite this large gap in the representation of fish remains between these two recovery methods, a

TABLE 5.15. NISP (NUMBER OF IDENTIFIED SPECIMENS)
SUMMARIZED BY CLASS AND PERIOD FOR BEZUAPAN
FLOTATION SAMPLES^a

	<i>LF</i>		<i>TF-I</i>		<i>TF-II</i>		<i>CL</i>	
	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)	(<i>n</i>)	(%)
Fish	83	72.8	369	38.7	93	36.3	130	30.2
Amphibians	0	0.0	31	3.2	5	2.0	11	2.6
Reptiles	2	1.8	87	9.1	3	1.2	1	0.2
Birds	1	0.9	8	0.8	0	0.0	25	5.8
Mammals	28	24.6	459	48.1	155	60.5	264	61.3
TOTALS	31		585		163		301	

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

clear pattern is discernible. The percentage of fish from flotation samples significantly declines after the Late Formative period. This pattern of change in Formative subsistence will be explored further in the quantitative analysis.

ANIMALS AND FARMING: THE GARDEN-HUNTING MODEL

The swidden farming system profoundly affects the natural landscape. From the home garden to the initial clearing of primary forestland for crop fields to the managed fallow, people directly manipulate the natural world. As humans disturb vegetation through the clearing and planting of fields and gardens, they provide new habitats for a wide variety of weedy pioneer plants that thrive in open habitats (Emslie 1981:317; Neusius 1996:276). The diversity and concentration of crops and weedy species, in turn, attracts insects, which attract animals that prey on those insects (Emslie 1981:317; Neusius 1996:276). Browsing animals are attracted to the new diversity of highly edible vegetation, which may include both wild and cultivated species. Ultimately, the changes wrought on the local environment through farming activities create habitats that favor a greater diversity and density of small animals than found in forested environments (Emslie 1981:317; Linares 1976:332; Neusius 1996:276; Speth and Scott 1989:71; Szuter 1994:55). While large animals like deer are also attracted to disturbed environments, the overall quantity and diversity of smaller animals is much greater. This anthropogenic process results in a local pool of readily available animal protein that humans can easily exploit. Thus, a new predator/prey cycle is established in disturbed environments that is qualitatively and quantitatively different than those in undisturbed, primary environments.

An increasing focus on farming to meet basic subsistence needs likely involved the reorganization of the larger subsistence system, which would have affected the organization of domestic labor. As people devoted more time to farming activities, scheduling other subsistence activities like hunting and fishing would have become more difficult. Of course, a farming/hunting gendered division of labor could have solved some of these scheduling problems. If farming evolved as an outgrowth of women's plant collection and management activities, then men would have been relatively free to continue their hunting and fishing activities without scheduling conflicts. However, in a region where people may have practiced year-round farming, there undoubtedly would have been critical

times in the farming cycle (e.g., during planting and harvest) when men and women alike would have participated in farming-related activities—these times would have probably precluded extended hunting or fishing trips.

The garden-hunting model proposes that people dealt with new scheduling conflicts by hunting and trapping animals inhabiting their fields and gardens (Emslie 1981:306; Linares 1976:331; Neusius 1996:276). Since many of these animals were crop pests, garden hunting served the dual purpose of providing protein to the diet and protecting crops from competitors (Emslie 1981:306; Neusius 1996:276; Szuter 1994:60). Following this line of reasoning, Neusius (1996:276) has argued that as farming became a more prominent subsistence activity, hunting, in turn, became a nonselective, opportunistic activity that increasingly occurred during other subsistence-related tasks. This change in hunting patterns would be reflected archaeologically by an increase in smaller (less desirable) prey and an increase in species diversity (Neusius 1996:276). This scenario supposes that people would have exploited a representative sample of the animals inhabiting agricultural fields, gardens, edge locales, and local areas of secondary vegetation, including animals that have traditionally been considered commensals (see also Szuter 1994; Szuter and Bayham 1989).

Linares (1976), who first proposed the garden-hunting model, argues for a more selective hunting strategy in which people focused their efforts on the larger species (in this case, white-tailed deer and peccary) attracted to their cleared and cultivated fields. She argues that white-tailed deer could withstand intensive harvesting by people (Linares 1976:347). Moreover, she suggests that an increased focus on garden hunting might displace the exploitation of aquatic fauna (Linares 1976:347). This strategy would be visible archaeologically by an overall increase in the proportion of terrestrial animals, and by a relative increase in large versus small mammals. As recent ethnographic studies in Amazonia have shown, however, local populations of large game surrounding farming communities soon become depleted by overhunting (Griffin 1989:69; Rai 1982:184–188; Vickers 1980; see also Speth and Scott 1989:75). Once people have depleted local levels of preferred larger game, they can either focus on less desirable smaller species (*à la* Neusius), or they can travel farther away from the residence to continue exploiting larger prey. Focusing on smaller game inhabiting fields and gardens adjacent to the house lot may have been a more attractive option, in that it would have (1) effectively dealt with scheduling conflicts between farming and hunting, (2) involved little effort or risk, in that procurement strategies would probably have in-

volved traps and snares (Coe and Diehl 1980b:106; Hovey and Rissolo 1999:261), (3) constituted a self-sustaining system, in that smaller mammals (e.g., rabbits) have high reproductive rates and would not have become locally depleted like deer, and (4) helped control losses to animals feeding on young plants or ripe crops.

Several archaeological studies focusing on the southwestern United States, however, have shown that people actually increased their exploitation of larger prey as they became more committed to farming (Speth and Scott 1989:76; Szuter and Bayham 1989:89). Obviously, the demands of the farming cycle constrained the time and labor that farmers could have devoted to long-distance hunting. Instead of opportunistically exploiting the numerous small animals inhabiting their fields and gardens, Speth and Scott (1989:77) argue that people chose to selectively focus on larger species that would have provided a higher return (see also Szuter and Bayham 1989:88). They suggest that when farmers were faced with local depletion of large prey, they extended their hunting ranges and shifted from an individually based to a communally based hunting strategy (Speth and Scott 1989:73; see also Vickers 1989:49). By combining their efforts, farmers would spend less time on long-distance hunts while procuring a higher return of preferred prey. Thus, there would have been fewer conflicts in terms of scheduling between farming tasks and communal hunting trips than with scheduling between farming tasks and individually based hunting trips.

Whether farmers choose a selective or an opportunistic hunting strategy may in part depend on how predictable their farming returns are. Maintaining a focus on large mammals is a risky venture, in that it requires a well-coordinated long-distance hunt that takes farmers away from their fields for a period of time. This type of high-risk selective hunting may imply a certain confidence in the farming cycle. As Speth and Scott (1989:77) state, "[T]he increased emphasis on large species among groups who obtain a substantial proportion of their total calories from cultivated plants may be a response . . . to the greater predictability of their horticultural food base." Thus, the high risk involved in a selective hunting strategy is offset by the minimal risk involved in the farming subsistence base. Of course, a few "well-coordinated long-distance" hunts could easily be scheduled around the farming calendar. Moreover, if people were practicing a gendered division of labor in which women were farming and men were hunting, occasional hunting trips would probably not have significantly impacted farming.

One could also argue that an opportunistic garden-hunting strategy implies that the subsistence economy may be somewhat stressed. For example, if people choose to eat any animal they come across, this suggests a “take what you can get” attitude, in which people do not have the luxury of being selective. Rather than being selective about the animals they exploit, people may choose to diversify—and diversification often represents a strategy of risk management or risk response (see Chapter 2). Thus, it is possible that a shift toward garden-hunting may reflect a response to a set of new risks associated with the transition to farming. However, the entire premise of the garden hunting strategy is the economy of resources. This conflict between garden hunting as risky and garden hunting as economical can be resolved if we simply uncouple “garden hunting” and “opportunistic.”

Does garden hunting have to be opportunistic? Just because local resources of large prey have been depleted and agricultural fields abound with small animals does not mean that farmers will not be selective about what they put in their mouths. While they may increasingly focus on the exploitation of small animals using a garden-hunting strategy, they may still be selective about which small animals they choose to eat. Thus, we might expect that farmers were more selective in their garden-hunting practices when farming was more predictable and harvests were good. In times of crop failure, however, people would have been faced with food shortages—they may have turned to opportunistic garden hunting as a way to buffer against shortages. This would be reflected archaeologically by high animal-species diversity. The following section examines these issues in more depth through the analysis of the zooarchaeological data from La Joya and Bezuapan.

QUANTITATIVE ANALYSIS: FORMATIVE ANIMAL EXPLOITATION THROUGH TIME

Here I present a quantitative analysis of the faunal remains from La Joya and Bezuapan. As with the plant data, sample sizes are generally small, especially for Bezuapan, so I restrict my analysis to temporal patterns. A spatial analysis of animal resources through time, though desirable, is simply not possible. As I explored the data, it became apparent that patterns of animal use differed dramatically between the two sites. Therefore, I chose to organize my discussion by site instead of by measure. While this approach departs from that employed in the previous chapter,

I believe it is necessary in order to provide a clear picture of animal exploitation at both La Joya and Bezuapan.

La Joya

Before launching into the quantitative analysis of animal exploitation through time, it is first necessary to consider non-cultural taphonomic agents that might have affected the composition of the faunal assemblages after the bones were discarded by humans. I collected data on the incidence of carnivore gnawing, rodent gnawing, root etching, and weathering on all bone specimens that could be assigned to a medium-large mammal category. These results are presented in Table 5.16. Unfortunately, the samples from the Middle Formative and Early Classic periods were rather small. Nevertheless, some patterns are evident. Patterns of carnivore gnawing, rodent gnawing, root etching, and weathering do not differ dramatically among the Early, Late, and Terminal Formative samples. The Middle Formative sample, however, appears to have a greater incidence of carnivore gnawing and root etching, and the mean weathering stage for this sample is slightly higher than for the other time periods. The Early Classic assemblage also has elevated levels of carnivore and rodent gnawing, when compared to the other samples. It seems that the Middle Formative and Early Classic assemblages may have been more ravaged by taphonomic processes than the Early, Late, and Terminal Formative samples. It is interesting that these are the periods with the smallest samples. Unfortunately, the white-tailed deer remains are too few to assess the effects of density-mediated attrition on these assemblages.

While these measures only begin to brush the surface of the taphonomic forces that the La Joya faunal assemblage has faced, they provide an important starting place for assessing the reliability of the assemblage for making inferences about resource use by Formative peoples. Because the Early, Late, and Terminal Formative samples are roughly comparable in terms of the taphonomic measures presented above, we can make a general assumption that these assemblages endured comparable levels of taphonomic bias, thus enabling further quantitative analysis. Moreover, the higher incidences of certain taphonomic signatures for the Middle Formative and Early Classic samples, coupled with the small sample sizes for these periods (see Table 5.4), implies the need for a certain amount of interpretative caution with regard to these assemblages. Because I am most concerned with the Formative period, I limit my discussion of the Early Classic period.

TABLE 5.16. TAPHONOMIC SUMMARY STATISTICS
BY PERIOD FOR LA JOYA

	Sample Size (n)	Carnivore Gnawing (%)	Rodent Gnawing (%)	Root Etching (%)	Mean Weathering Stage
Early Classic	77	35.3	9.1	2.6	1.454
Terminal Formative	417	7.7	2.9	3.4	1.733
Late Formative	146	2.7	4.1	2.7	1.643
Middle Formative	86	17.4	1.2	23.3	2.197
Early Formative	422	5.5	0.7	7.6	1.803

Class-based Comparisons. To explore broad trends in the exploitation of animals through time, I begin with a consideration of taxonomic class (e.g., reptiles, birds, etc.). One of the most notable trends is the increase in mammals from the Early to Late Formative periods, followed by a subsequent decrease during the Terminal Formative period (Figure 5.1). Figure 5.1 graphically illustrates this pattern using % NISP and % MNI. Although Figure 5.1 shows only a slight increase in mammals from the Early through Late Formative periods, this increase is more apparent in terms of % bone weight and % NISP of fauna from flotation samples² (Tables 5.6–5.9). This increase in mammals from the Early to Late Formative periods is paralleled by a decrease in the relative percent of fish, reptiles, and birds, and an increase in the relative percent of amphibians (Tables 5.6–5.9). This is to be expected, given that relative percentages are dependent measures—in order for one percentage to increase, another must decrease.

To deal with this problem of dependence, I calculated ratios of fish, amphibian, reptile, and bird NISP standardized to white-tailed deer NISP. There are both advantages and disadvantages to using white-tailed deer as a standardizer for class-based comparisons. Two advantages to using deer for this measure are: (1) white-tailed deer is independent of the other taxonomic classes; and (2) white-tailed deer was identified for all time periods. A disadvantage is that if deer NISP is not a constant variable throughout the sequence, then changes in the abundance of deer would affect the resulting ratios. However, based on the % NISP of white-tailed deer from La Joya, the abundance of deer is roughly comparable throughout the sequence (see Table 5.4).

The class-based ratios are presented in Table 5.17 and illustrated

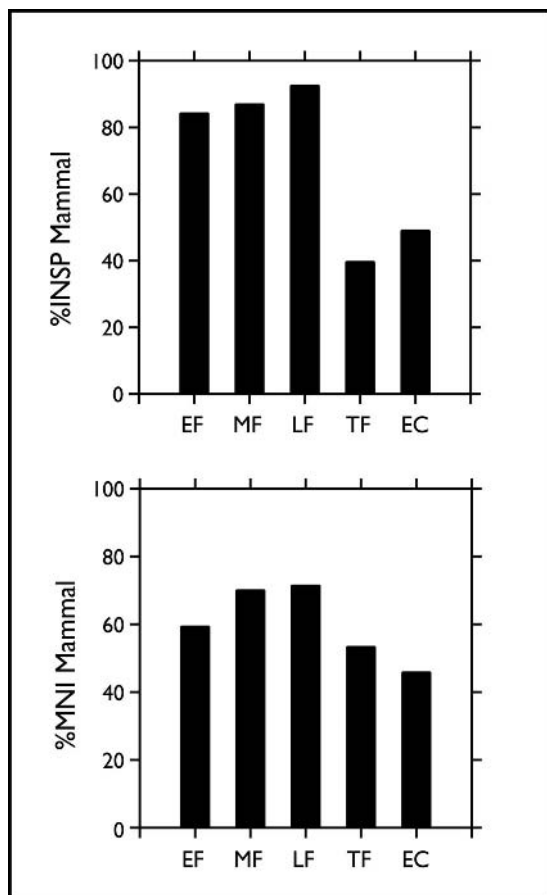


FIGURE 5.1. *Percent of mammals for La Joya by period (NISP, MNI).*

graphically in Figure 5.2. Overall, these ratios mirror the patterns evident in the relative percentages of NISP, MNI, bone weight, and flotation NISP. The contribution of birds and fish declines markedly after the Early Formative and remains low throughout the Late Formative, only to increase again during the Terminal Formative period. Reptiles are fairly unimportant throughout the Early, Middle, and Late Formative periods, but increase dramatically during the Terminal Formative period. Likewise, the contribution of amphibians increases dramatically during the Terminal Formative and continues to increase into the Early Classic period.

Together, these patterns suggest a trend toward an increasing focus on mammals from the Early to Late Formative periods. After the Late For-

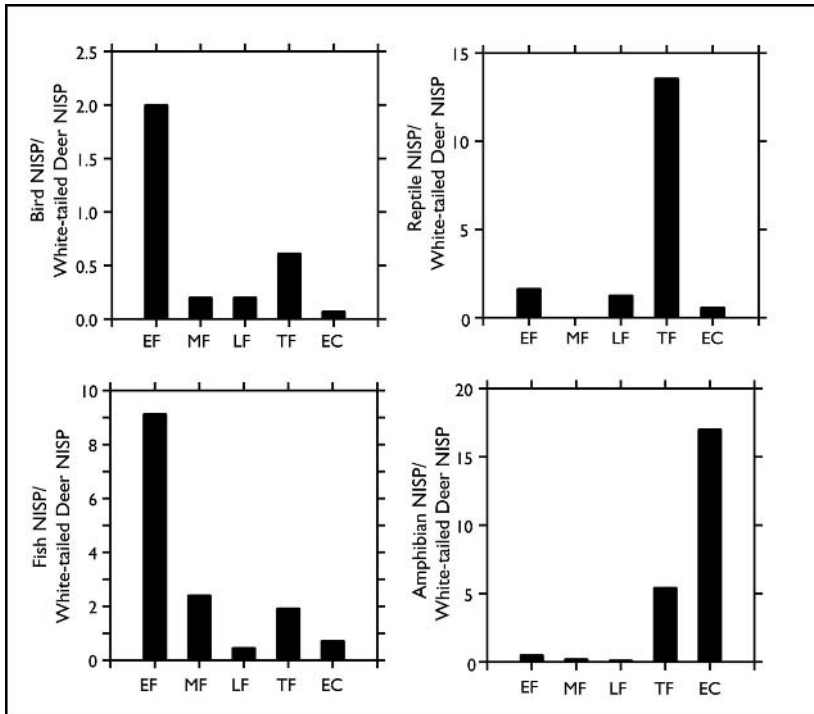


FIGURE 5.2. *Animal class: white-tailed deer ratios for La Joya by period (NISP).*

TABLE 5.17. RATIOS OF FISH, AMPHIBIANS, TURTLES, AND BIRDS TO WHITE-TAILED DEER (NISP) FOR LA JOYA^a

	EF	MF	LF	TF	EC
Fish to white-tailed deer ratio	9.13	2.40	0.45	1.92	0.71
Amphibians to white-tailed deer ratio	0.50	0.20	0.10	5.42	17.00
Reptiles to white-tailed deer ratio	1.63	0.00	1.25	13.56	0.57
Birds to white-tailed deer ratio	2.00	0.20	0.20	0.61	0.07

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

mative period, however, people appear to have widened their net by exploiting proportionally more birds, fish, and reptiles. The reversal of subsistence trends from earlier periods is interesting, and is a pattern that reappears throughout the analysis. This diversification of animal procurement during the Terminal Formative period may represent a response to

either a decline in yields from primary resources (e.g., mammals), or an increase in subsistence risk, though the cause and nature of such a risk are unclear and a topic to which I will return later in the chapter. The increase in amphibians during this time, accounted for mostly by toads, may relate to increasing sedentism, and perhaps longer household structure duration. As mentioned earlier, the toads native to the region are attracted to human disturbance and tend to burrow under people's houses (Lee 2000:86–88).

Species Diversity. The class-based patterns suggest that people narrowed their subsistence base from Early to Late Formative times, after which they diversified during the Terminal Formative period. Given these patterns, and in light of the garden-hunting model presented above, I measure species diversity for all time periods. I calculate diversity based on NISP and use Kintigh's (1984, 1989) DIVERS computer simulation.

Figures 5.3 and 5.4 plot richness and evenness, respectively, against sample size for each period. The center line in the DIVERS plot represents the expected evenness or richness, and the lines around the center line represent the 90% confidence interval for the expected values. Actual values are labeled.

The Early Formative animal assemblage is significantly richer than expected (Figure 5.3). The Middle and Late Formative and Early Classic assemblages fall below the expected range of richness values. The Terminal Formative animal assemblage falls well within the expected range of richness values, given its sample size. In terms of richness, the Early Formative assemblage is significantly more diverse than later assemblages. After the Early Formative period, assemblage richness drops well below expected values. During the Terminal Formative period, animal assemblage diversity increases again, though this value is still not as high as during the Early Formative period.

The DIVERS evenness values are roughly similar to the richness values (Figure 5.4). The Middle Formative assemblage is the only sample that falls within the 90% confidence interval for its expected range of evenness values. The Early Formative assemblage is more evenly distributed than expected, falling above the 90% confidence interval. The Late and Terminal Formative and Early Classic samples, however, fall below the confidence interval, indicating that these assemblages are significantly less evenly distributed than expected. It is notable, however, that the Late Formative and Early Classic samples fall much further below their expected range of values than the Terminal Formative sample.

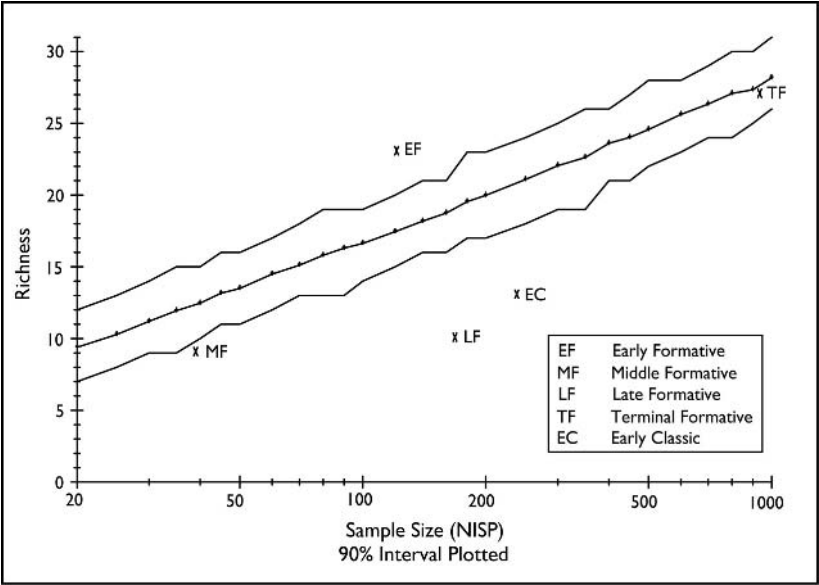


FIGURE 5.3. *DIVERS richness plot of La Joya animal remains by period.*

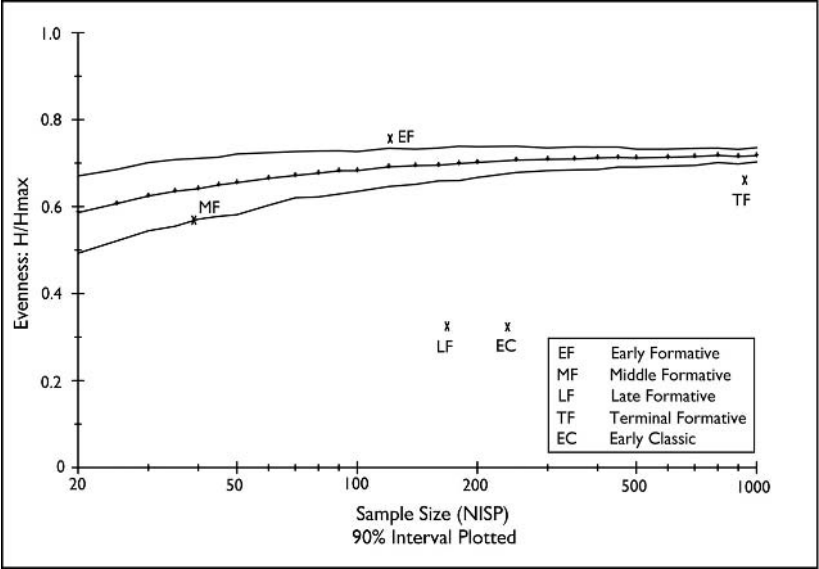


FIGURE 5.4. *DIVERS evenness plot of La Joya animal remains by period.*

Overall, the DIVERS results suggest that the Middle and Late Formative residents of La Joya exploited fewer types of prey than the preceding Early Formative residents. After the Late Formative period, La Joya residents began exploiting a wider range of species again, a strategy similar to the one employed during the Early Formative occupation at the site. The major difference between Early and Terminal Formative hunting strategies at La Joya seems to be the extent to which people exploited individual taxa—Early Formative residents exploited animals to a similar degree, whereas Terminal Formative residents focused more on specific taxa.

This pattern might reflect the level of risk that the residents of La Joya perceived to be a factor in their subsistence system. During the Early Formative period, the residents of La Joya were still mobile and relatively new farmers. They may have chosen to offset the risk of a new venture by exploiting a wide range of potential food sources (*sensu* Speth and Scott 1989:77). As they became more adept at farming, the risk of failure lessened and people became more selective in the animals they chose to exploit for food. During the Terminal Formative period, however, it appears that La Joya residents may have perceived a new risk, one that led them to diversify their animal resource base again, this time capturing more birds, reptiles, and fish than during earlier periods.

Terrestrial versus Aquatic Taxa. Linares (1976:347) suggested that as people became more agricultural, they would have increasingly procured terrestrial disturbance fauna, a subsistence shift that would have displaced the reliance on aquatic fauna. I test this expectation by calculating the % NISP of aquatic taxa through time at La Joya (Figure 5.5). Aquatic taxa identified at La Joya include fish, turtles, and waterfowl. The unidentified turtles were not included in this measure, as they might represent terrestrial species. However, all bird specimens identified to the family Anatidae were included, as this family is composed entirely of waterfowl. Figure 5.5 reveals that the Early, Middle, and Late Formative residents of La Joya exploited fewer aquatic taxa through time. Aquatic taxa compose only 10% of the NISP during the Early and Middle Formative periods, and even less during the Late Formative. During the Terminal Formative period, however, this figure increases dramatically to 24%. These patterns reveal that La Joya residents decreasingly focused on aquatic species until the Terminal Formative period, when they began to exploit aquatic habitats to a greater extent than before.

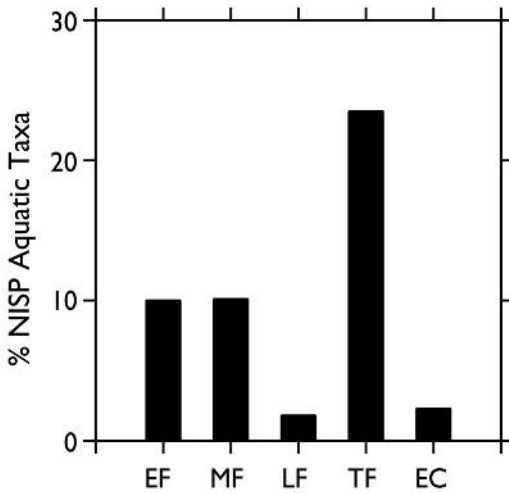


FIGURE 5.5. *Percent of aquatic taxa for La Joya by period (NISP).*

Disturbance Taxa. The presence of disturbance taxa in an assemblage represents two different processes. When people clear land to farm, they create new “disturbed” habitats which support a greater diversity and density of terrestrial fauna than primary habitats. Thus, an increase in disturbance fauna in an archaeological assemblage reflects both an anthropogenic modification of the local environment (e.g., field clearance) and a choice made by people to exploit animals inhabiting local disturbed environments. A decrease in disturbance fauna, however, does not necessarily reflect a decrease in the creation of disturbed habitats, or by extension a decrease in agricultural field clearance. Rather, a decrease in disturbance fauna may simply reflect a choice made by people to exploit fauna from other habitats.

To examine this process at La Joya, I began by assigning each species identified to primary and secondary habitats (see Table 5.3). Information on habitat preferences was collected from modern field guides and ecological studies of the region (Coe and Diehl 1980b; Howell and Webb 1995; Lee 2000; Reid 1997; Soriano et al. 1997). Because animals are not fixed onto the landscape, this was not a straightforward task. Many animals identified in the assemblages inhabited as many as five habitat zones. As a result, I simplified my approach by creating a simple dichotomy of animals that prefer disturbed habitats and those that do not (Table 5.18). Disturbance species include animals that prefer secondary growth and

forest edge areas, animals that can be considered agricultural pests, and animals that take refuge in and around human habitations. The disturbance species listed in Table 5.18 include both commensal and food species.

I calculated the percentage of disturbance fauna by period using NISP, MNI, and presence (Table 5.19). Because dogs are domestic animals and aquatic taxa are restricted to bodies of water, they are excluded from these measures. Commensal animals that are also disturbance fauna are included in these measures; I also consider commensal taxa separately below (see Table 5.20). All three disturbance fauna measures yielded similar patterns. The percentages for the Middle Formative period equal 100% for all three measures, likely a result of small sample size. If we simply ignore the Middle Formative values, we find that the percentage of disturbance fauna is roughly comparable during the Early and Late Formative periods. After the Late Formative, there is a subsequent decline in the % NISP of disturbance fauna in the Terminal Formative period.

If we consider commensal fauna separately, a slightly different pattern emerges (Table 5.20). The percentage of commensals during the Early and Late Formative periods are roughly comparable, a pattern similar to that in Table 5.19.³ During the Terminal Formative period, however, the percentage of commensal taxa increases, in contrast to the decrease in overall disturbance fauna at this time (see Table 5.19). Thus, while Terminal Formative residents of La Joya appear to have exploited less overall disturbance fauna than during previous periods, there is a higher incidence of commensals at this time.

These patterns suggest a high level of field clearance through time, accounting for the high percentages of disturbance fauna through the Late Formative period. Not only were the residents of La Joya creating anthropogenic habitats through field clearance, they were also choosing to exploit the animals inhabiting those niches. In some cases, they were probably just getting rid of pests like mice and rats, but in other cases they were procuring animal protein through garden hunting. The subsequent decrease in disturbance fauna during the Terminal Formative period does not necessarily mean that people were clearing fewer fields and creating fewer anthropogenic habitats. Rather, this decline in disturbance fauna is probably linked to the increase in species diversity and aquatic fauna during that time. In addition to focusing more on birds, reptiles, and fish as food resources, it appears that the Terminal Formative residents of La Joya also exploited terrestrial and arboreal species that prefer primary,

TABLE 5.18. REGIONAL DISTURBANCE FAUNA IDENTIFIED AT LA JOYA

<i>Regional Disturbance Fauna</i>	<i>Identified at La Joya</i>
POTENTIAL FOOD TAXA	
Swainson's hawk	Hawk (<i>Buteo</i> sp.) ^a
Opossum	Opossum
Deppe's squirrel	Squirrel (<i>Sciurus</i> sp.) ^b
Mexican gray squirrel	Squirrel (<i>Sciurus</i> sp.) ^b
Hispid pocket gopher	Hispid pocket gopher
Eastern cottontail	Rabbit (<i>Sylvilagus</i> sp.) ^b
Forest rabbit	Rabbit (<i>Sylvilagus</i> sp.) ^b
Northern raccoon	
Ocelot	Ocelot
Collared peccary	Collared peccary
White-tailed deer	White-tailed deer
COMMENSAL TAXA	
Cane toad	Toad (<i>Bufo</i> sp.) ^b
Gulf Coast toad	Toad (<i>Bufo</i> sp.) ^b
Coues' rice rat	Coues' rice rat
Hispid cotton rat	Hispid cotton rat
White-footed mouse	Mouse (<i>Peromyscus</i> sp.) ^b
Aztec mouse	Mouse (<i>Peromyscus</i> sp.) ^b

^aSpecific taxonomic identification was not possible. Because not all species within this genus represent disturbance taxa in the study region, this generic taxon was not included in the analysis as disturbance fauna.

^bSpecific taxonomic identification was not possible. However, because all species within this genus present in the study region represent disturbance taxa, this generic taxon was included in the analysis as disturbance fauna.

undisturbed habitats. Indeed, it seems as if they were procuring any type of animal that they could.

The increase in commensal fauna during the Terminal Formative period probably relates to a combination of factors, including longer house structure duration and an increase in food storage. The increase in toads may be an indicator of longer structure duration, in that native toads like to burrow under human habitations (see above). Moreover, Arnold (2000) has identified an increase in the presence and size of subsurface storage pits during the Late and Terminal Formative periods. These storage

TABLE 5.19. DISTURBANCE TAXA THROUGH TIME
AT LA JOYA (NISP, MNI, PRESENCE)^{a,b}

	<i>EF</i>	<i>MF</i>	<i>LF</i>	<i>TF</i>	<i>EC</i>
NISP of disturbance taxa	93	29	154	337	216
Total NISP ^c	101	29	157	766	228
% NISP of disturbance taxa	92.1	100	98.1	44.0	94.7
MNI of disturbance taxa	17	7	8	37	17
Total MNI	22	7	12	48	20
% MNI of disturbance taxa	77.3	100	66.7	77.1	85.0
N of disturbance taxa present	15	6	6	13	7
N of total taxa present ^c	19	6	9	19	9
% Presence of disturbance taxa	78.9	100	66.7	68.4	77.8

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

^bCalculations include commensal taxa, but exclude aquatic taxa and domestic dog.

^cThis figure excludes unidentified specimens. Specimens identified to family are included only if that family is not represented in the assemblage by genus or species.

TABLE 5.20. COMMENSAL TAXA THROUGH TIME AT
LA JOYA^{a,b}

	<i>EF</i>	<i>MF</i>	<i>LF</i>	<i>TF</i>	<i>EC</i>
NISP of commensal taxa	18	12	5	285	212
Total NISP ^c	104	31	157	779	233
% NISP of commensal taxa	17.3	38.7	3.2	36.6	91.0
MNI of commensal taxa	6	4	3	28	15
Total MNI	22	7	12	48	20
% MNI of commensal taxa	27.3	57.1	25.0	58.3	75.0
N of commensal taxa present	5	4	2	6	6
N of total taxa present	20	7	9	20	10
% Presence of commensal taxa	25.0	57.1	22.2	30.0	60.0

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

^bCalculations exclude aquatic taxa and domestic dog.

^cThis figure excludes unidentified specimens. Specimens identified to family are included only if that family is not represented in the assemblage by genus or species.

facilities were probably used to store maize (Arnold 2000) and would have attracted mice and rats. Thus, it is possible that residents of La Joya were storing more food during the Terminal Formative than in previous periods. This increase in food storage probably relates to the intensification of maize production at this time and may be an indicator of increasing yields (see also Chapter 4). More importantly, the increase in storage may be a risk management response by Terminal Formative people, in that food storage is a strategy that buffers against food shortage at both the production and consumption levels (see also Chapter 2).

Large versus Small Taxa. To further explore changes in hunting strategies through time, I consider the subsistence contribution of large versus small prey. I calculate this for both mammals and the entire vertebrate assemblage based on MNI (Tables 5.21, 5.22). I use MNI because it minimizes the effects of fragmentation between different-sized classes of animals. NISP tends to over-represent larger animals, since their bones tend to break into more pieces. Because I am interested in identifying changes in hunting strategies of large versus small animals, it is important to use a measure that estimates individuals and minimizes the effects of bone fragmentation. Because this is a measure of terrestrial hunting strategies, I have excluded commensal taxa, aquatic taxa, and domestic dogs from these calculations. Sample sizes for the Middle Formative and Early Classic are generally small. Nevertheless, it is clear from Tables 5.21 and 5.22 that the ratios of large to small prey remained relatively stable through time. Thus, while the types of habitats exploited by La Joya residents may have changed through time, the relative subsistence contribution of large versus small prey did not.

Summary of La Joya Faunal Patterns. In sum, the data presented above reveal several interesting trends in faunal procurement at La Joya. From the Early through Late Formative periods, residents of La Joya appear to have increasingly focused on terrestrial taxa, and mammals in particular. The high percentages of disturbance fauna in the Early through Late Formative assemblages point to a focus on garden hunting throughout this time. Because most of the hunting took place in disturbed habitats near the settlement, people probably did not travel far to procure faunal resources. Thus, this focus on garden hunting indicates that hunting was largely embedded in farming-related tasks. The decreases in species richness and evenness during this span of time also suggest that people became more selective about the animals they chose to exploit. Based on the

TABLE 5.21. RATIOS OF LARGE:SMALL MAMMALIAN TAXA FOR LA JOYA THROUGH TIME^{a,b}

	<i>EF</i>	<i>MF</i>	<i>LF</i>	<i>TF</i>	<i>EC</i>
LARGE MAMMALS					
Collared peccary	1			1	
White-tailed deer	1	1	2	2	1
Red brocket deer	1			1	
Large mammal MNI	3	1	2	4	1
SMALL MAMMALS					
Opossum	1		2	2	1
Nine-banded armadillo				1	
Squirrel	1			1	
Hispid pocket gopher	2	1	2	2	
Rabbit	1	1	1	1	1
Ocelot	2				
Small mammal MNI	7	2	5	7	2
LARGE:SMALL MAMMAL RATIO	0.43	0.5	0.4	0.57	0.5

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

^bDogs and commensal taxa excluded.

garden hunting model presented above, this increase in prey selectivity from the Early through Late Formative periods may indicate that farming had become a more dependable and less risky venture.

During the Terminal Formative, however, these trends in animal use reverse. At this time the residents of La Joya began to exploit a wider range of habitats, procuring more animals from aquatic and primary forest habitats. An increase in species richness and evenness during the Terminal Formative supports this pattern. This expansion of the hunting territory may have involved more time away from the houses and fields. Nevertheless, an increase in food storage coupled with the plant data presented in Chapter 4 indicates that La Joya residents intensified maize production at this time. Volcanic eruptions at the end of the Late Formative period (see Chapter 3) would have affected the abundance of local fauna and may have limited the availability of good farmland during the subsequent Terminal Formative period. Residents of La Joya may have responded to these new subsistence limitations by focusing more intensively

TABLE 5.22. RATIOS OF ALL LARGE:SMALL VERTEBRATE FOR LA JOYA THROUGH TIME^{a,b}

	<i>EF</i>	<i>MF</i>	<i>LF</i>	<i>TF</i>	<i>EC</i>
LARGE ANIMALS					
Collared peccary	1			1	
White-tailed deer	1	1	2	2	1
Red brocket deer	1			1	
Large animal MNI	3	1	2	4	1
SMALL ANIMALS					
Musk turtle				1	1
Slider				1	
Green iguana	1			3	1
Boa constrictor				2	
Muscovy duck				1	
Duck	1		1	1	
Hawk	1			1	
Wild turkey	1		1		
Northern bobwhite	1			1	
Yellow-bellied sapsucker	1				
Opossum	1		2	2	1
Nine-banded armadillo				1	
Squirrel	1			1	
Hispid pocket gopher	2	1	2	2	
Rabbit	1	1	1	1	1
Ocelot	2				
Small animal MNI	13	2	7	18	4
LARGE:SMALL ANIMAL RATIO	0.23	0.5	0.29	0.22	0.25

^aEarly Formative (EF), Middle Formative (MF), Late Formative (LF), Terminal Formative (TF), Early Classic (EC).

^bDogs and commensal taxa excluded.

on fewer maize fields and widening their hunting range. People probably dealt with scheduling conflicts related to hunting and farming by dividing subsistence-related tasks among different genders and age groups. Overall, these patterns suggest that the Terminal Formative residents of La Joya may have been faced with increasing subsistence risk, possibly related to local environmental catastrophe (volcanic eruptions and ashfall), in addition to tribute demands by regional leaders in the face of local

recovery from environmental catastrophe. The implications of this will be discussed at the conclusion of this chapter.

Bezuapan

I present the data from Bezuapan in the same manner as I did for La Joya. Although the sample sizes for Bezuapan are somewhat smaller, certain patterns are still evident. I begin with a consideration of taphonomic factors that may have affected the composition of the Bezuapan faunal assemblage. As with La Joya, I calculated the percentages of carnivore gnawing, rodent gnawing, and root etching, in addition to mean weathering stage, as observed on all medium-large mammal specimens. These data are presented by period in Table 5.23. The Late Formative and Terminal Formative–I samples yielded the highest percentages of carnivore gnawing, at 11.1% and 20.4%, respectively. The Late Formative sample also yielded a higher percentage of rodent gnawing than the other samples. Despite the effects of carnivore and rodent gnawing on the large mammal remains from these periods, the Late Formative and Terminal Formative–I samples still yielded higher ratios of large to small mammals than the assemblages from later periods (see Tables 5.28, 5.29). This suggests that the effects of gnawing, while undoubtedly resulting in the destruction of some bones, did not affect the assemblages to the extent that large mammals became underrepresented in the samples. Because these taphonomic factors were not serious enough to lead to an under-representation of large mammals during the Late and Terminal Formative–I periods, we can cautiously assume some level of comparability between the samples from Bezuapan. Overall, the Terminal Formative–II sample seemed the least affected by the vagaries of taphonomy, in terms of all measures observed. As with La Joya, the Classic period sample was most affected by root etching, which likely speaks to its deposition closer to the ground surface. As with La Joya, however, I focus more on the Formative occupations of the site than on the subsequent Classic period occupation.

Class-based Comparisons. To examine general patterns of faunal exploitation through time at Bezuapan, I first consider taxonomic class (e.g., reptiles, birds, etc.). In contrast to La Joya, the percentage of mammals increases somewhat during the Terminal Formative period—this increase from the Late Formative is apparent during both Terminal Formative occupations at the site when calculated by % NISP, % bone weight, and %

TABLE 5.23. TAPHONOMIC SUMMARY STATISTICS BY PERIOD FOR BEZUAPAN

	<i>Sample Size (n)</i>	<i>Carnivore Gnawing (%)</i>	<i>Rodent Gnawing (%)</i>	<i>Root Etching (%)</i>	<i>Mean Weathering Stage</i>
Classic	72	4.2	1.4	11.1	2.53
Terminal Formative–II	296	5.4	0.7	2.7	1.86
Terminal Formative–I	142	20.4	2.8	2.8	2.27
Late Formative	63	11.1	12.7	3.2	2.05

NISP from flotation samples (Tables 5.12, 5.14, 5.15; Figure 5.6). The representation of amphibians also increases through time, apparent in terms of all measures observed (Tables 5.12–5.15). The increase in mammals and amphibians is paralleled by a decrease in fish and birds throughout the Formative sequence (Tables 5.12–5.15). Unfortunately, the data do not agree in terms of the relative percentage of reptiles throughout the sequence. In terms of % NISP, the contribution of reptiles decreases significantly after the Late Formative. Other measures, however, document an increase in reptiles during both the Terminal Formative–I and Terminal Formative–II occupations. The decrease in the % NISP of reptiles after the Late Formative period is probably skewed by the large quantity of unidentified snake specimens found in the Late Formative sample—these specimens were all vertebral elements and probably come from the same snake. Moreover, because percentages are dependent measures, the large increase in amphibian specimens during the Terminal Formative–II occupation significantly affected the percentage of reptiles.

Because of the dependency problem inherent in relative percentages, I use ratios to assess the dietary contribution of fish, amphibians, reptiles, and birds through time at Bezuapan. As with La Joya, I calculate independent ratios of fish, amphibian, reptile, and bird NISP standardized to white-tailed deer NISP. Results are presented in Table 5.24 and illustrated graphically in Figure 5.7. These results support the patterns apparent in the relative percentages. The ratios of fish and bird NISP to white-tailed deer NISP decrease throughout the Formative period and rebound during the Classic.

The contribution of reptiles also declines dramatically after the Late Formative occupation, but increases slightly during the second Terminal

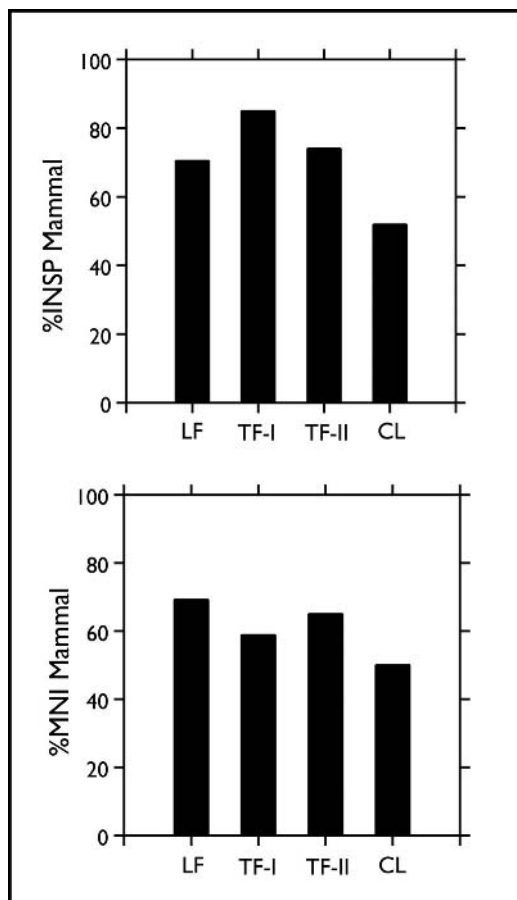


FIGURE 5.6. *Percent of mammals for Bezuapan by period (NISP, MNI).*

Formative occupation (though this ratio is not nearly as high as during the Late Formative). The ratio of amphibians to white-tailed deer also increases throughout the site's occupational history, paralleling the relative percentages presented in Tables 5.12 and 5.13.

These patterns suggest that the shift from the Late to Terminal Formative period at Bezuapan involved a shift away from the exploitation of birds, fish, and reptiles, and toward mammals. This pattern parallels the trend observed at La Joya from the Early to Late Formative period, although this trend had reversed itself at La Joya by the Terminal Formative period. It is curious that the Terminal Formative residents at

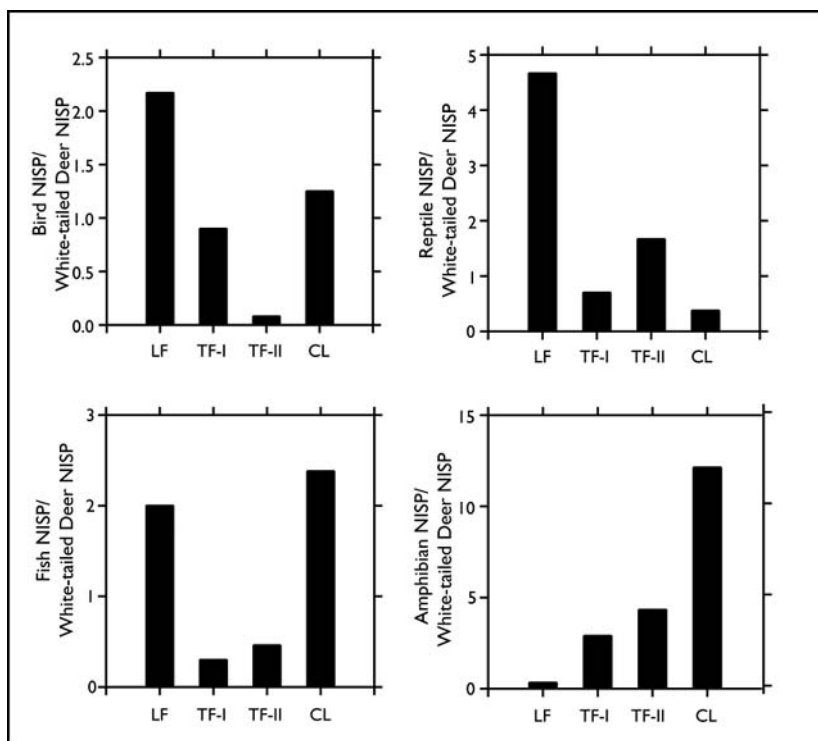


FIGURE 5.7. *Animal class: white-tailed deer ratios for Bezuapan by period (NISP).*

TABLE 5.24. RATIOS OF FISH, AMPHIBIANS, TURTLES, AND BIRDS TO WHITE-TAILED DEER (NISP) FOR BEZUAPAN^a

<i>Ratio</i>	<i>LF</i>	<i>TF-I</i>	<i>TF-II</i>	<i>CL</i>
Fish to white-tailed deer ratio	2.00	0.30	0.46	2.38
Amphibian to white-tailed deer ratio	0.33	2.90	4.33	12.13
Reptile to white-tailed deer ratio	4.67	7.00	1.67	0.38
Bird to white-tailed deer ratio	2.17	0.90	0.08	1.25

^aLate Formative (LF), first Terminal Formative occupation (TF-I), second Terminal Formative occupation (TF-II), Classic (CL).

Bezuapan were shifting away from the exploitation of reptiles, birds, and fish, while the residents of La Joya were shifting toward the exploitation of these animal classes. The increase in the representation of amphibians throughout Bezuapan's occupation was also documented at La Joya, and likely reflects increasing sedentism, and perhaps longer house structure duration.

Species Diversity. The class-based patterns suggest that the residents of Bezuapan increasingly narrowed their subsistence base to focus on mammals throughout the Formative occupation. Analysis of species diversity, however, paints a different picture. As with La Joya, I calculate diversity based on NISP using Kintigh's (1984, 1989) DIVERS computer simulation.

Figures 5.8 and 5.9 plot richness and evenness, respectively, against sample size for each period. The center line in the plot represents the expected richness or evenness, and the lines around the center line represent the 90% confidence interval around the expected values. Actual values are labeled.

The plots for richness and evenness are almost identical. Both the Late Formative and Classic period assemblages fall below the expected values for richness and evenness. The Terminal Formative assemblages, however, fall within the expected ranges of both richness and evenness. These results indicate that the Late Formative residents of Bezuapan focused on relatively fewer animals than subsequent Terminal Formative residents. During the Terminal Formative period, people widened their prey selection and stopped targeting specific animals. These patterns reversed during the Classic period, when people began targeting fewer animals again.

These patterns, coupled with the increase in the relative percent of mammals through time, reveal that the residents of Bezuapan were increasingly exploiting a wider range of mammalian taxa through time in relatively equal proportions. The increase in richness and evenness during the Terminal Formative period translates into a shift toward an opportunistic, nonselective hunting strategy, a shift similar to that documented at La Joya during the Terminal Formative period. This shift toward nonselective faunal procurement may have been a response to an increasing risk in the subsistence base, perhaps the same risk with which the Terminal Formative residents of La Joya were faced. Unlike the residents of La Joya, however, the residents of Bezuapan chose to concentrate their efforts on mammals. In other words, although they selectively ex-

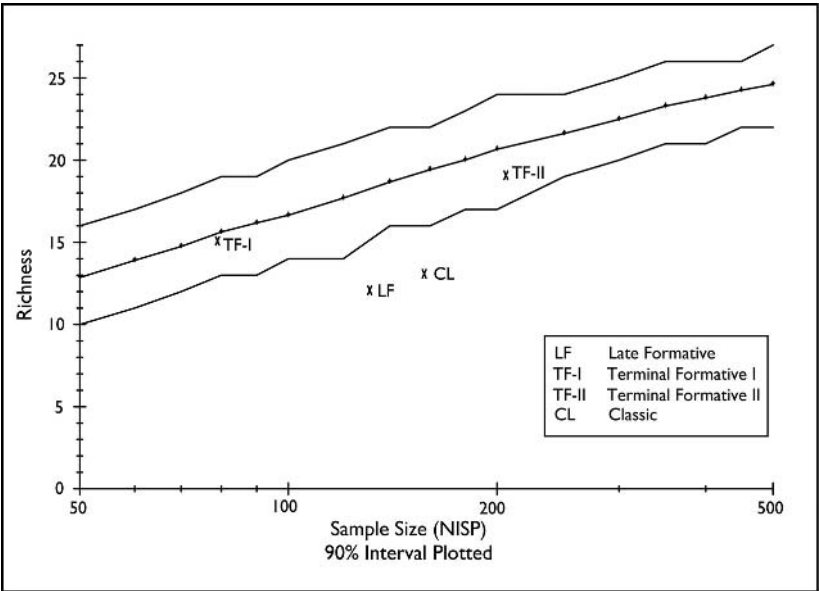


FIGURE 5.8. *DIVERS richness plot of Bezuapan animal remains by period.*

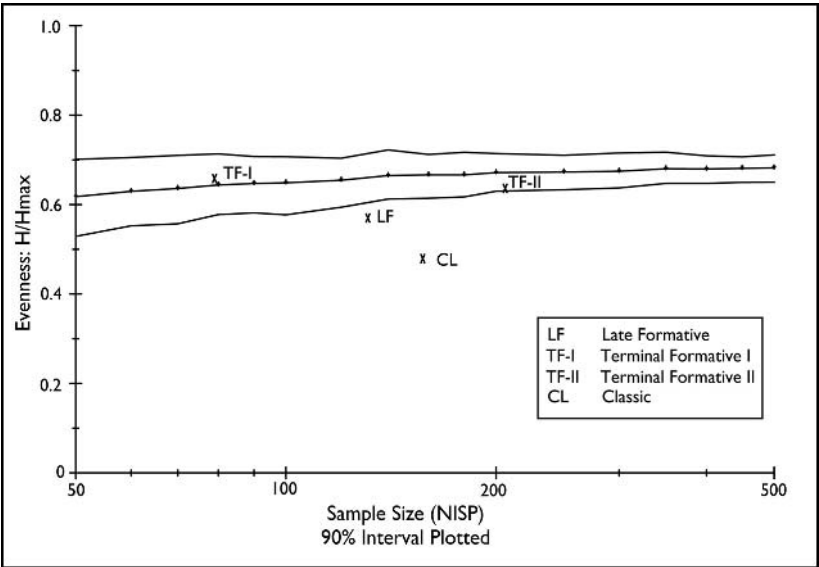


FIGURE 5.9. *DIVERS evenness plot of Bezuapan animal remains by period.*

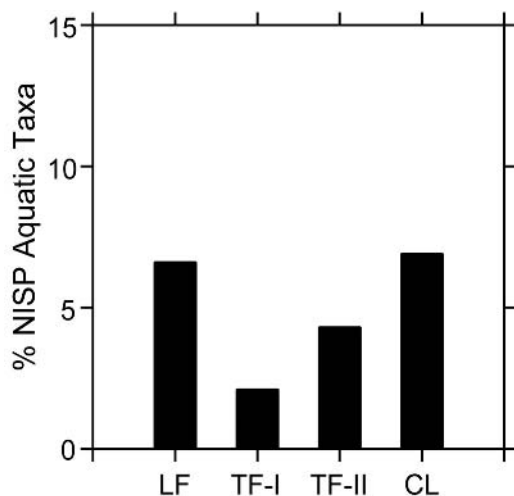


FIGURE 5.10. Percent of aquatic taxa for Bezuapan by period (NISP).

ploited mammals over species from other taxonomic classes, they evidently were not picky about which mammals they procured.

Terrestrial versus Aquatic Taxa. Given the increasing focus on mammals by the Terminal Formative residents of Bezuapan, it is reasonable to expect a shift toward the exploitation of terrestrial fauna. Moreover, an increasing focus on terrestrial fauna over aquatic fauna is also an expectation of the garden-hunting model. To test this expectation, I calculated the % NISP of aquatic taxa through time at Bezuapan (Figure 5.10). Aquatic taxa identified at Bezuapan include fish, turtles, and waterfowl. The unidentified turtles were not included in this measure, as they might represent terrestrial species. All bird specimens identified to the family Anatidae were included, as this family is composed entirely of waterfowl. Figure 5.10 reveals a decrease in aquatic taxa after the Late Formative period, followed by a subsequent (though minor) increase during the second Terminal Formative occupation. Overall, the increase only amounts to 5% and may not be all that meaningful. Nevertheless, the overall low percentages of aquatic fauna throughout the site's occupation are another indicator that the residents of Bezuapan focused their efforts on terrestrial animals throughout the site's tenure.

Disturbance Taxa. Disturbance fauna identified at Bezuapan are listed in Table 5.25. I calculated the percentage of disturbance fauna based on

NISP, MNI, and presence (Table 5.26). As with La Joya, these measures exclude aquatic taxa, domestic dog, and unidentified specimens. Commensal animals that are also disturbance fauna are included in these measures; I also consider commensals separately in Table 5.27.

According to measures of MNI and presence, the percentage of disturbance fauna remains fairly constant throughout the Formative occupation of the site, increasing only during the Classic period. When calculated by NISP, however, this percentage increases dramatically after the Late Formative period, yielding high values during both Terminal Formative occupations and the subsequent Classic occupation (82.8%,

TABLE 5.25. REGIONAL DISTURBANCE FAUNA IDENTIFIED AT BEZUAPAN

<i>Regional Disturbance Fauna</i>	<i>Identified at Bezuapan</i>
POTENTIAL FOOD TAXA	
Swainson's hawk	Hawk (<i>Buteo</i> sp.) ^a
Opossum	Opossum
Deppe's squirrel	Squirrel (<i>Sciurus</i> sp.) ^b
Mexican gray squirrel	Squirrel (<i>Sciurus</i> sp.) ^b
Hispid pocket gopher	Hispid pocket gopher
Eastern cottontail	Rabbit (<i>Sylvilagus</i> sp.) ^b
Forest rabbit	Rabbit (<i>Sylvilagus</i> sp.) ^b
Northern raccoon	Northern raccoon
Ocelot	
Collared peccary	Collared peccary
White-tailed deer	White-tailed deer
COMMENSAL TAXA	
Cane toad	Toad (<i>Bufo</i> sp.) ^b
Gulf Coast toad	Toad (<i>Bufo</i> sp.) ^b
Coues' rice rat	Coues' rice rat
Hispid cotton rat	Hispid cotton rat
White-footed mouse	Mouse (<i>Peromyscus</i> sp.) ^b
Aztec mouse	Mouse (<i>Peromyscus</i> sp.) ^b

^aSpecific taxonomic identification was not possible. Because not all species within this genus represent disturbance taxa in the study region, this generic taxon was not included in the analysis as disturbance fauna.

^bSpecific taxonomic identification was not possible. However, because all species within this genus present in the study region represent disturbance taxa, this generic taxon was included in the analysis as disturbance fauna.

TABLE 5.26. DISTURBANCE TAXA THROUGH TIME AT BEZUAPAN (NISP, MNI, PRESENCE)^{a,b}

	<i>LF</i>	<i>TF-I</i>	<i>TF-II</i>	<i>CL</i>
NISP of disturbance taxa	32	48	133	120
Total NISP ^c	83	58	174	141
% NISP of disturbance taxa	38.6	82.8	76.4	85.1
MNI of disturbance taxa	5	10	11	10
Total MNI	9	14	17	12
% MNI of disturbance taxa	55.6	71.4	64.7	83.3
N of disturbance taxa present	5	8	9	5
N of total taxa present	9	12	16	8
% Presence of disturbance taxa	55.6	66.7	56.3	62.5

^aLate Formative (LF), Terminal Formative I (TF-I), Terminal Formative II (TF-II), Classic (CL).

^bCalculations include commensal taxa but exclude aquatic taxa and domestic dog.

^cThis figure excludes unidentified specimens. Specimens identified to family are included only if that family is not represented in the assemblage by genus or species.

76.4%, and 85.1%, respectively). These patterns differ from those identified at La Joya, where the percentage of disturbance fauna actually decreased during the Terminal Formative period. Whereas the residents of La Joya diversified their faunal exploitation during the Terminal Formative to include animals from a variety of different habitats, the residents of Bezuapan instead focused their faunal procurement efforts on animals that prefer disturbed habitats. Indeed, it seems as if the residents of Bezuapan actually increased their exploitation of disturbance fauna during the Terminal Formative period, or at the very least they practiced garden hunting to the same extent during the Terminal Formative as they had during the Late Formative. The data presented thus far indicate that the transition to the Terminal Formative period at Bezuapan involved a shift toward garden hunting of an increasingly diverse range of terrestrial mammals.

If we consider commensal fauna separately, a similar pattern emerges. In terms of NISP, the percentage of commensals increases from the Late Formative through the Classic period. In terms of MNI and presence, however, the percentage of commensals is much lower for the first Termi-

nal Formative occupation (TF-I) than for the other occupations. Nevertheless, the second Terminal Formative sample (TF-II) yielded high percentages of commensals across the board.

These patterns suggest a high level of field clearance through time. The increase in disturbance fauna during the Terminal Formative period suggests that the residents of Bezuapan may have created more anthropogenic habitats during the Terminal Formative period than they had during the Late Formative. Alternately, Terminal Formative people at the site may have simply exploited local disturbance fauna more intensively than before. This increase in disturbance fauna probably represents a combination of pest control (e.g., in terms of mice and rats) and exploitation for food. The increase in commensals suggests that pest control was necessary—the increase in rodents during the Terminal Formative period is probably indicative of increased food storage at this time (see also Pool 1997). An increase in food storage (see Chapter 3) probably reflects

TABLE 5.27. COMMENSAL TAXA THROUGH TIME
AT BEZUAPAN^{a,b}

	<i>LF</i>	<i>TF-I</i>	<i>TF-II</i>	<i>CL</i>
NISP of commensal taxa	7	23	113	114
Total NISP ^c	83	58	174	145
% NISP of commensal taxa	8.4	39.7	64.2	78.6
MNI of commensal taxa	3	2	8	8
Total MNI	9	14	17	12
% MNI of commensal taxa	33.3	14.3	47.1	66.7
	3	1	8	4
N of commensal taxa present				
N of total taxa present ^d	9	12	17	9
% Presence of commensal taxa	33.3	8.3	47.1	44.4

^aLate Formative (LF), Terminal Formative I (TF-I), Terminal Formative II (TF-II), Classic (CL).

^bCalculations exclude aquatic taxa and domestic dog.

^cThis figure excludes unidentified specimens. Specimens identified to family are included only if that family is not represented in the assemblage by genus or species, with the exception of specimens identified to the mice/rat family (Muridae) as these represent commensal taxa.

^dThis figure includes the mouse/rat family (Muridae) as its own category because it represents commensal taxa.

increases in maize yields and correlates well with evidence of intensive maize cultivation at this time (see Chapter 4). Overall, it appears that the Terminal Formative residents of Bezuapan increasingly focused on mammals that inhabited their fields and gardens. The time saved through trapping animals in disturbed areas adjacent to the residence may have been invested in intensive maize farming. Indeed, increased food storage as evidenced by more underground storage (Pool 1997) and vermin may reflect higher maize yields during the Terminal Formative period.

Large versus Small Taxa. To further explore changes in hunting strategies through time, I consider the subsistence contribution of large versus small prey. As with La Joya, I calculate this for both mammals and the entire vertebrate assemblage based on MNI (Tables 5.28, 5.29). I use MNI instead of NISP because it minimizes the effects of fragmentation between different-sized classes of animals (see above). Again, I exclude commensal taxa, aquatic taxa, and domestic dogs from these calculations.

Both measures reveal similar patterns—the ratio of large to small prey increases slightly during the first Terminal Formative period, then decreases dramatically during the second Terminal Formative occupation. These results are consistent with the garden-hunting model. With the shift to a focus on garden hunting during the first Terminal Formative occupation, the residents of Bezuapan focused their efforts on large prey. This focus on large prey likely led to the overhunting, and hence depletion, of these taxa in the local environment.⁴ At this point, the residents of Bezuapan had to make a choice between a focus on large prey and one on garden hunting. Rather than expand their hunting ranges and travel farther in order to continue procuring preferred large species, the residents of Bezuapan instead focused their efforts on garden hunting and were thus forced to take a greater proportion of smaller prey. This choice, apparent in the data, speaks to the importance that the people of Bezuapan placed on their commitment to farming. Interestingly, this decrease in the exploitation of large prey during the second Terminal Formative occupation corresponds with an increase in the harvesting of avocados (see Chapter 4). While a focus on avocados would not have made up for a loss in protein, it would have substituted for the saturated fats available from animal meat.

Summary of Bezuapan Faunal Patterns. In sum, the faunal data from Bezuapan indicate an increasing focus on terrestrial mammals that prefer disturbed habitats, a pattern which points to the increasing importance of

TABLE 5.28. RATIOS OF LARGE:SMALL MAMMALIAN TAXA FOR BEZUAPAN THROUGH TIME^{a,b}

	LF	TF-I	TF-II	CL
LARGE MAMMALS				
Collared peccary		1		
White-tailed deer	1	2	1	1
Red brocket deer	1	1	1	
Large mammal MNI	2	4	2	1
SMALL MAMMALS				
Opossum	1	1		
Nine-banded armadillo	1	1	1	1
Squirrel	1	1	1	
Hispid pocket gopher			1	1
Rabbit		1	1	
Raccoon		1	1	
Small mammal MNI	3	5	5	3
LARGE:SMALL MAMMAL RATIO	0.67	0.8	0.4	0.33

^aLate Formative (LF), Terminal Formative I (TF-I), Terminal Formative II (TF-II), Classic (CL).

^bDogs and commensal taxa excluded.

garden hunting. While the exploitation of large prey initially increased during the shift to garden hunting, the probable depletion of large prey in the local environment led people to resort to the procurement of smaller, less preferred taxa. Moreover, the increase in species diversity throughout the Formative period indicates that people became less selective about what animals they were willing to eat. Indeed, it seems as if people were willing to eat anything, so long as they could procure it close to home. While the increase in commensals may simply indicate an increase in pests associated with an increase in food storage, it is possible that people exploited mice and rats for food. The decrease in selectivity with respect to faunal procurement may reflect an increase in subsistence-related risk. It is possible that when faced with volcanic eruption and ashfall at the end of the Late Formative period, the residents of Bezuapan chose to intensify their garden hunting in order to remain close to their fields and focus their efforts more intensively on farming. The shift away from selective faunal procurement and toward opportunistic garden hunting also signifies a shift in labor away from hunting and fishing and toward farming

TABLE 5.29. RATIOS OF ALL LARGE:SMALL VERTEBRATE FAUNA FOR BEZUAPAN THROUGH TIME ^{a,b}

	<i>LF</i>	<i>TF-I</i>	<i>TF-II</i>	<i>CL</i>
LARGE ANIMALS				
Collared peccary		1		
White-tailed deer	1	2	1	1
Red brocket deer	1	1	1	
Large animal MNI	2	4	2	1
SMALL ANIMALS				
Musk turtle		1	1	1
Slider	1		1	
Green iguana			1	
Muscovy duck		1		
Hawk		1		
Wild turkey	1	1	1	1
Opossum	1	1		
Nine-banded armadillo	1	1	1	1
Squirrel	1	1	1	
Hispid pocket gopher			1	1
Rabbit		1	1	
Raccoon		1	1	
Small animal MNI	5	9	9	4
LARGE : SMALL ANIMAL RATIO	0.4	0.44	0.22	0.25

^aLate Formative (LF), Terminal Formative I (TF-I), Terminal Formative II (TF-II), Classic (CL).

^bDogs, commensal taxa, and fish excluded.

tasks. Thus, it seems that the Terminal Formative residents of Bezuapan chose to deal with increasing subsistence risk by investing more time and labor into agriculture, while diversifying their selection of disturbance mammals.

DISCUSSION

The data presented above reveal that regional changes in subsistence practices were not monolithic processes in the Tuxtlas. The choices made by the people of Bezuapan with respect to faunal procurement during the Terminal Formative period differed dramatically from those made by the

people at La Joya. Based on the patterns in the data, I have argued that subsistence became riskier during the Terminal Formative period. When faced with this risk, the residents of La Joya and Bezuapan responded differently. At La Joya, people chose to reallocate labor away from farming and toward the exploitation of animal resources from a variety of habitats. At Bezuapan, however, people chose to invest more time and labor in their fields and to supplement their diets by harvesting more avocados and intensively and opportunistically garden hunting.

But why did subsistence become more risky during the Terminal Formative period? It is interesting that the periods of increasing risk identified at La Joya and Bezuapan correspond to periods of volcanic activity in the region. Three definite volcanic eruptions occurred during the Formative period—the first during the late Early Formative/early Middle Formative (1250–900 BC), the second near the end of the Late Formative (150 BC), and the third during the Terminal Formative period (AD 150–250) (Pool 1990; Reinhardt 1991; Santley et al. 1984). The Late Formative eruption postdates the Late Formative occupation at Bezuapan. Moreover, both Terminal Formative occupations at Bezuapan and the Terminal Formative occupation at La Joya were sealed with layers of volcanic ash, indicating their abandonment just prior to, and presumably as a result of, ashfall (Arnold 2000, pers. comm.; Pool 1997).

While volcanic ash would have had a positive effect on local soil fertility in the long term, the short-term effects of ashfall would have been devastating (see also Chapter 3). The volcanic activity documented in the Tuxtlas during the Formative period would have adversely affected maize production in the region, destroying existing crops and limiting the growth potential of new ones. The abundance and distribution of local fauna would also have been affected. At La Joya, Early Formative people dealt with the combined risk of beginning a new venture (farming) and volcanic ashfall by exploiting a diverse range of animals from a wide array of habitats. Once the residents of La Joya had become seasoned farmers and the perceived risk of volcanic activity had lessened, they began to focus more on farming and shifted to garden hunting to provide the bulk of their animal protein. After the volcanic eruptions toward the end of the Late Formative period and during the Terminal Formative period, the subsistence base became less predictable. La Joya villagers responded by again expanding their hunting territory and exploiting any animal they came across, in addition to relying more on tree fruits than they had during earlier periods (see Chapter 4).

The villagers at Bezuapan, however, responded differently to the threat

of volcanic eruption. While they exploited a more diverse range of animals during the Terminal Formative than they had during the Late Formative, they chose to remain closer to home and put more time and labor into food production. Indeed, the increase in storage volume at Bezuapan from the first to second Terminal Formative occupation indicates an increase in surplus storage (see Pool 1997). Their response to the increase in subsistence risk during this time, however, was not wholly unlike that of the La Joya villagers. The residents of Bezuapan also chose to harvest more tree fruits than they had during the previous occupation. When large game became depleted during the Terminal Formative period, residents of Bezuapan offset the loss of this preferred source of fat by harvesting and consuming more avocados.⁵

Volcanic eruption and ashfall would have certainly affected the sustainability of different subsistence practices and the choices people made with respect to subsistence. But why did the residents of La Joya and Bezuapan organize their subsistence economy so differently during the Terminal Formative period? To understand why, we must consider La Joya and Bezuapan in terms of larger regional political developments. Survey data indicate the emergence of a regional center during the Late Formative period at the site of Chuniapan de Abajo, located approximately 6–7 km southwest of La Joya and Bezuapan (see also Chapter 3). By the Terminal Formative period, the regional population had dwindled, though a three-tiered political hierarchy was nevertheless maintained, this time centered at the site of Chuniapan de Arriba, just a few kilometers south of La Joya and Bezuapan. Evaluating whether agricultural tribute flowed from La Joya and Bezuapan into these regional centers would require a comparative analysis of subsistence remains from multiple sites in the regional site hierarchy—an analysis not currently possible, given the available data. Nevertheless, we can speculate about the nature of regional tribute mobilization. It is possible that elites at these local centers encouraged village leaders from La Joya and Bezuapan to mobilize surplus agricultural goods for their benefit (see also Pool 1997). Whether or not regional leaders had the power to enforce their tribute demands to the extent that their demands would have stressed village-level subsistence is another issue altogether. Villagers from La Joya and Bezuapan could have simply left the region—indeed, half of the regional population did leave during the Terminal Formative period (Santley et al. 1997). Although a three-tiered regional site hierarchy may have been present in the Tuxtlas during the Late and Terminal Formative periods, it appears that regional political power may have become fragmented during the Terminal Formative period

(McCormack 1996; Santley et al. 1997; see also Pool 2000; Stark 1997). Based on differences in kernel-to-cupule ratios between La Joya and Bezuapan, I suggest in Chapter 4 that these two settlements may have been differentially integrated into the regional political hierarchy during the Terminal Formative period. Higher levels of maize processing at Bezuapan may suggest that the site's residents had greater tribute obligations than people from La Joya. Indeed, the faunal data presented in this chapter suggest that the residents of Bezuapan were more committed to farming at this time. It is possible that Bezuapan villagers focused their efforts on farming, despite the effects of ashfall, because they had to fulfill tribute obligations. La Joya villagers may have simply ignored their tribute obligations during this time of subsistence hardship. Or, perhaps La Joya was more negatively impacted by volcanic activity than Bezuapan, and regional elites simply reduced or deferred their tribute payments. At this point, any discussion of tribute is simply speculation. Nevertheless, the differences between La Joya and Bezuapan in terms of response to increasing subsistence risk cannot be explained by environmental factors alone. The differences in the subsistence decisions made by the Terminal Formative residents of La Joya and Bezuapan were likely conditioned by their involvement in regional politics.

The data presented thus far paint a picture of increasing subsistence risk associated with volcanic activity. These two cases provide examples about the different choices made by people when faced with similar circumstances. Although environmental conditions may have constrained the set of options available to the residents of La Joya and Bezuapan, Formative people in the Tuxtlas were the agents who effected the changes necessary to maintain economic self-sufficiency at the village level.

EATING PLANTS AND ANIMALS:
STABLE ISOTOPIC ANALYSIS OF
HUMAN, DOG, AND DEER BONES

Although floral and faunal data can reveal much about past subsistence economy, they represent lines of evidence that are often difficult to compare analytically. These two lines of evidence differ both in terms of preservation and recovery biases. Thus, assessing the relative contribution of plants versus animals in the diet using these data is not feasible. Moreover, because the plant and animal remains we recover archaeologically represent only a fraction of what was originally deposited—a fraction biased by a variety of different taphonomic factors—we cannot use these data to determine the absolute contribution of different food resources in the diet. There are, however, other methods that address this issue. Stable carbon and nitrogen isotope analysis uses skeletal material to trace prehistoric food intake at the individual level. Rather than quantifying the food that people discarded, this method quantifies the food that people actually consumed through an analysis of bone chemistry. Ultimately, stable isotope analysis can help us to determine an individual's dependence on terrestrial versus marine resources, as well as different types of plant foods. Here I examine the absolute dietary contributions of terrestrial and marine plants and animals to the Formative diet through an analysis of stable carbon and nitrogen isotopes. I begin with an introduction to the method of stable isotope analysis, followed by a discussion of sampling and methodology. Finally, I present the results and consider them in relation to the plant and animal data presented in the previous chapters.

STABLE ISOTOPE ANALYSIS

Certain food resources have distinct isotopic signatures that are incorporated into bone collagen, bone apatite carbonate, and dental enamel, and can be preserved for thousands of years. These isotopic signatures are expressed as ratios of carbon ($^{13}\text{C}/^{12}\text{C}$) and nitrogen ($^{15}\text{N}/^{14}\text{N}$). The amount of carbon and nitrogen in an animal's tissues is controlled metabolically, and hence the ratios of carbon ($^{13}\text{C}/^{12}\text{C}$) and nitrogen ($^{15}\text{N}/^{14}\text{N}$)

in an animal's tissues reflect the same stable isotope as that in the animal's diet (Price et al. 1985:429). By measuring these isotopes in archaeological skeletal samples, it is possible to determine which types of foods formed the mainstay of an individual's diet. The results of this type of bone chemistry analysis represent several years of food consumption for each individual sampled, and thus seasonal and long-term variation in consumption is averaged over time (Ambrose 1987; Chisholm and Nelson 1982; Price et al. 1985; Schoeninger and Moore 1992).

Carbon and nitrogen isotopes are measured using a mass spectrometer (Schoeninger and Moore 1992:253). Bone collagen is either treated chemically or combusted at a high heat to free carbon dioxide (CO_2) and nitrogen (N_2) gases (Schoeninger and Moore 1992:253). During this process, the gas from the sample is compared to a laboratory standard calibrated to international standards. The international standard for carbon is the PeeDee Belemnite Carbonate (PDB), a marine carbonate (Ambrose 1987:82; DeNiro 1987:182; Price et al. 1985:430; Schoeninger and Moore 1992:254). The standard for nitrogen is the ambient inhalable reservoir (AIR)—this became the standard once it had been demonstrated that the isotope ratio of N_2 in the atmosphere is constant worldwide (Ambrose 1987:92; DeNiro 1987:182; Price et al. 1985:430; Schoeninger and Moore 1992:254). Most biological materials have less ^{13}C relative ^{12}C than the international standard (PDB), and thus most samples will yield negative $\delta^{13}\text{C}$ values (Schoeninger and Moore 1992:254). In terms of nitrogen, however, most biological materials have higher $^{15}\text{N}/^{14}\text{N}$ ratios than the international standard (AIR), and thus most samples will yield positive $\delta^{15}\text{N}$ values (Schoeninger and Moore 1992:254). The mathematical equations for determining these values are as follows:

$$\delta^{13}\text{C} = \frac{[^{13}\text{C}/^{12}\text{C}_{\text{sample}} - ^{13}\text{C}/^{12}\text{C}_{\text{PDB}}] \times 1000\text{‰}}{^{13}\text{C}/^{12}\text{C}_{\text{PDB}}}$$

$$\delta^{15}\text{N} = \frac{[^{15}\text{N}/^{14}\text{N}_{\text{sample}} - ^{15}\text{N}/^{14}\text{N}_{\text{AIR}}] \times 1000\text{‰}}{^{15}\text{N}/^{14}\text{N}_{\text{AIR}}}$$

During photosynthesis in terrestrial plants and chemosynthesis in marine plants, carbon is transferred from the atmosphere and ocean into living biological systems (Ambrose 1987:94; Schoeninger and Moore 1992:255). Because there is more ^{13}C in oceanic carbon dioxide than atmospheric carbon dioxide, the carbon isotopic signatures for terrestrial and marine plants are often distinctly different (Schoeninger and Moore 1992:255;

but see below). Moreover, $\delta^{13}\text{C}$ values for terrestrial plants also vary according to a plant's particular photosynthetic pathway (Ambrose 1987; DeNiro 1987; Norr 1995; Schoeninger and Moore 1992; van der Merwe 1982). There are three pathways available to a terrestrial plant during photosynthesis: C_3 , C_4 , and CAM pathways. C_3 plants include temperate grasses, trees, fruits, and tubers, all of which yield very negative $\delta^{13}\text{C}$ values (average value approximately -26‰) (DeNiro 1987:184; Norr 1995:200; Schoeninger and Moore 1992:256). C_4 plants include some amaranths and chenopods, and tropical grasses like maize (average $\delta^{13}\text{C}$ value approximately -12‰) (DeNiro 1987:184; Norr 1995:200; Schoeninger and Moore 1992:255). The distribution of $\delta^{13}\text{C}$ values for C_3 and C_4 plants is bimodal, with very little overlap (Ambrose 1987:94). CAM plants yield $\delta^{13}\text{C}$ values that encompass the range of C_3 and C_4 plants, and are represented mostly by succulents (DeNiro 1987:184; Norr 1995:200). Marine organisms use several sources of carbon, and thus there is some overlap in $\delta^{13}\text{C}$ values between marine animals and terrestrial plants (Schoeninger and Moore 1992:256; Figures 6.1, 6.2). Specifically, C_4 plants yield $\delta^{13}\text{C}$ values that are very similar to those of marine species—thus, in studies in which maize is a potential food source, it is difficult to distinguish between marine and terrestrial resources, based on collagen-based carbon isotopes alone (Chisholm and Nelson 1982:1132; Keegan and DeNiro 1988:321). It is therefore important to conduct isotopic analysis on bone apatite carbonate in addition to collagen, as a dual consideration of collagen and apatite carbonate can allow for the differentiation of protein and carbohydrate portions of the diet, respectively (Norr 2002; Schoeninger and Moore 1992; Schwarcz and Schoeninger 1991). Unfortunately, only collagen was extracted for isotopic analysis of the materials from La Joya and Bezuapan. Because collagen is mostly protein-based, it is important to keep in mind that the data presented below highlight dietary protein but not carbohydrates, which makes distinguishing between maize and shellfish somewhat tricky.

Because maize and marine fauna differ more dramatically in terms of $\delta^{15}\text{N}$ values, nitrogen isotopes can be used to differentiate between these resources in situations where they were both possible food resources. Nitrogen is transferred into the biological system through two processes: N_2 -fixation and organic decomposition (DeNiro 1987:184; Price et al. 1985:431; Schoeninger and Moore 1992:256). Both blue-green algae and bacterial nodules on terrestrial plants (e.g., legumes) fix nitrogen (see Chapter 4), and the process of organic decomposition produces nitrates that are absorbed by plants. N_2 -fixing plants yield more negative $\delta^{15}\text{N}$

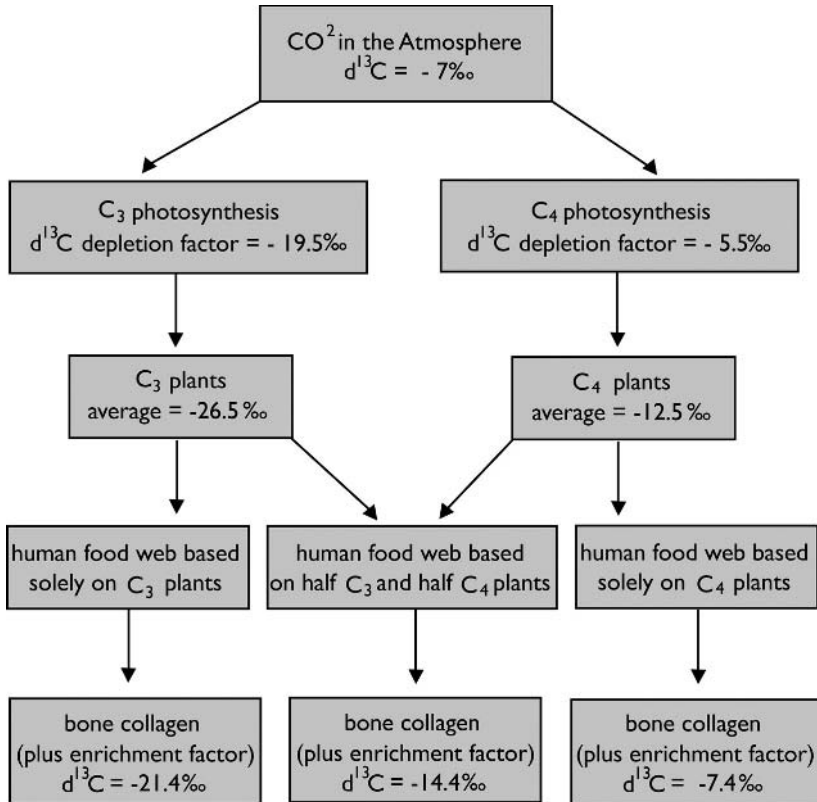


FIGURE 6.1. *Carbon in the terrestrial food chain.* (Adapted from Nikolaas J. van der Merwe, "Carbon Isotopes, Photosynthesis, and Archaeology, *American Scientist* 70[1982]: 596–606.) In Figures 6.1–6.5, $\delta = \delta$.

values than plants using nitrates (Schoeninger and Moore 1992:256). Moreover, $\delta^{15}\text{N}$ values for marine plants are more positive than those for terrestrial plants (Norr 1995:200; Schoeninger and Moore 1992:256; Figure 6.3).

When interpreting $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values, it is important to consider trophic-level effects (Ambrose 1987; Schoeninger and Moore 1992). For example, when herbivores feed on plants, they increase their levels of carbon and nitrogen relative to the plants on which they feed. This process continues up through the food web. While this process is barely discernible in terms of carbon (only 1‰), trophic-level effects for nitrogen are much more dramatic (3‰) (Ambrose 1987:95; Schoeninger and Moore 1992:258). Trophic-level effects between terrestrial and marine systems,

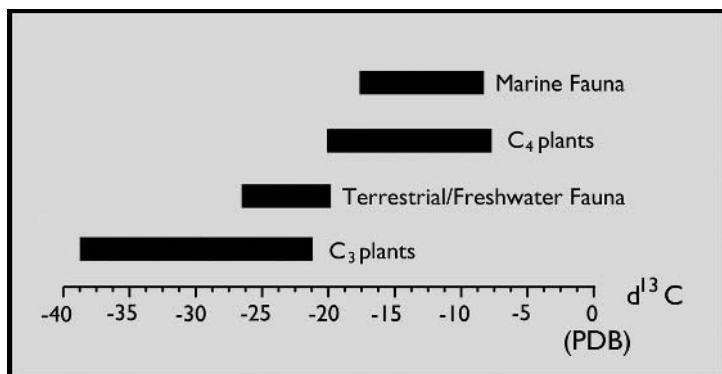


FIGURE 6.2. $\delta^{13}\text{C}$ values for plant and animal resources in nature. (Reprinted from Lynette Norr, "Prehistoric Subsistence and Health Status of Coastal Peoples from the Panamanian Isthmus of Lower Central America," in *Paleopathology at the Origins of Agriculture*, ed. M. N. Cohen and G. J. Armelagos, p. 473, Copyright 1984, with permission from Elsevier.)

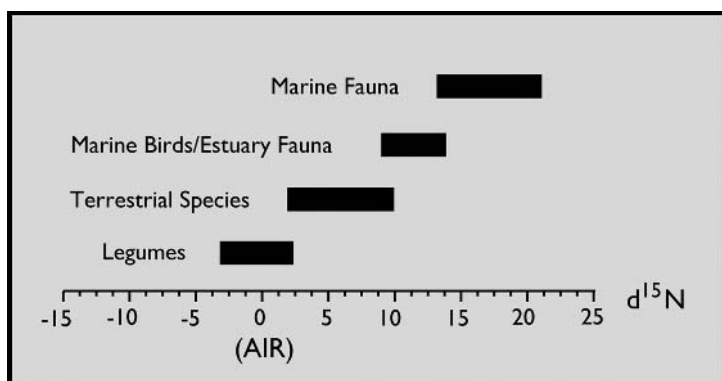


FIGURE 6.3. $\delta^{15}\text{N}$ values for plant and animal resources in nature (Reprinted from Lynette Norr, "Prehistoric Subsistence and Health Status of Coastal Peoples from the Panamanian Isthmus of Lower Central America," in *Paleopathology at the Origins of Agriculture*, ed. M. N. Cohen and G. J. Armelagos, p. 474, Copyright 1984, with permission from Elsevier.)

however, are not comparable, as the source nitrogen for these systems is significantly different. Moreover, these effects will vary between different ecological and geographic systems, and thus it is important to measure $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values from various plant and animal food resources from the same study area as the archaeological samples—such values will provide a template for interpreting the skeletal data.

SAMPLING AND METHODS

Bone specimens selected for stable isotope analysis included the remains of human, white-tailed deer, red brocket deer, and domestic dog (Table 6.1). Samples were submitted to Dr. Mark Schurr at the Fluoride Dating Service Center, University of Notre Dame, and were processed by Dr. Laura Cahue. Only three human burials were encountered during the excavations at La Joya, and all of them date to the Terminal Formative occupation. Five human interments were excavated at Bezuapan—four of these individuals date to the first Terminal Formative occupation at the site, and the other to the Classic period. These individuals were aged and sexed by Theresa Linda Jolly (Jolly 1998a, 1998b). Specimens were preferentially taken from the ribs whenever possible. However, when poor preservation prohibited the selection of rib fragments, specimens were chosen from miscellaneous bone fragments. This sampling methodology should not bias the study results—as DeNiro and Schoeninger (1983) have demonstrated, there are no significant differences in the isotopic signatures of collagen from different skeletal elements. A total of 25 white-

TABLE 6.1. SPECIMENS TAKEN FOR CARBON AND NITROGEN ISOTOPIC ANALYSIS

	<i>White-tailed Deer</i>	<i>Red Brocket Deer</i>	<i>Domestic Dogs</i>	<i>Humans</i>
LA JOYA				
Early Formative	4		2	
Middle Formative	3		2	
Late Formative	3		1	
Late/Terminal Formative	2			
Terminal Formative	3		4	2
Terminal Formative/Early Classic				1
TOTALS	15		9	3
BEZUAPAN				
Late Formative	2		3	
Terminal Formative—I	3		3	6(4) ^a
Terminal Formative—II	5	1	2	
Classic				1
TOTALS	10	1	8	7

^aNumber of Individuals in parentheses.

tailed deer and 17 domestic dog skeletal specimens were taken from La Joya and Bezuapan for isotopic analysis. These samples derive from various contexts spanning the entire Formative sequence at these sites. In addition, one red brocket deer skeletal sample from Bezuapan was also submitted for analysis.

RESULTS

Because of geographic and ecological variation in the isotopic signatures of different plants and animals, it is necessary to sample local flora and fauna (both modern and archaeological) to provide a template of carbon and nitrogen ratios for interpreting the human skeletal samples. Given the time and budgetary constraints of this project, I was only able to submit samples from archaeological deer and dog toward this end. Moreover, there have been no other stable isotope analyses in the Tuxtlas that would have collected isotopic data on local flora and fauna. Thus, I draw on research from Central America in order to construct a template for interpreting my data (Norr 1995; Wright 1997). Both Norr and Wright conducted their research in tropical environments (Panama and Guatemala, respectively) that yielded species lists of flora and fauna comparable to those encountered in the Tuxtlas. Ultimately, it is my goal to collect isotopic data on modern flora and fauna from the study area. For the present study, however, I must rely on analogy to the isotopic composition of modern and archaeological foods from tropical Central America (Figure 6.4).

Sample quality was assessed based on collagen yield from bone and C/N ratios (see Ambrose 1990; Ambrose and Norr 1992; DeNiro 1985; Norr 1995). Of the 53 samples submitted for analysis, 40 either yielded too little collagen from which to calculate carbon and nitrogen ratios or were too diagenetically altered to use the results. Thus, only 13 specimens provided useful results. These results are presented in Table 6.2 and illustrated graphically in Figure 6.5.

Of the results listed in Table 6.2, the human sample is composed of four human skeletal specimens representing three individuals: a subadult, an adult female, and an adult whose sex was indeterminate. Although this sample of human individuals is too low to make any generalizations about Formative dietary practices, it is nevertheless the only isotopic data available for this region and thus provides a starting point for assessing the contributions of different food resources during the Terminal Formative period. All human specimens yielded comparable $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values. The carbon values fall between -10.06 and -11.19 , well within the range

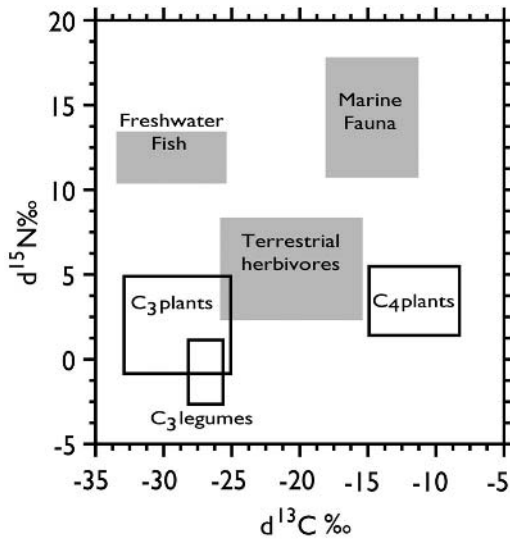


FIGURE 6.4. *Isotopic composition of archaeological foods from Central America. (Modified from Norr 1995:201 and Wright 1997:187; reprinted with the permissions of Cambridge University Press and Smithsonian Institution Press.)*

TABLE 6.2. CARBON AND NITROGEN ISOTOPIC RATIOS FOR THE STUDY SITES^a

	Site	Period	C/N Ratio	% Yield	δ ¹³ C	δ ¹⁵ N
Human ^b	LJ	TF	2.73	5.78	-10.33	7.42
Human ^{c,d}	BZ	TF-I	2.80	8.58	-10.06	9.35
Human ^{c,d}	BZ	TF-I	2.74	8.14	-10.21	8.99
Human ^{d,e}	BZ	TF-I	2.86	1.53	-11.19	8.63
Domestic dog	BZ	LF	2.79	4.89	-11.46	4.67
Domestic dog	LJ	TF	2.78	27.61	-12.78	7.91
Domestic dog	BZ	TF-I	3.23	3.48	-9.47	3.16
White-tailed deer	LJ	MF	3.14	6.50	-21.95	1.91
White-tailed deer	BZ	LF	2.79	3.15	-19.26	3.74
White-tailed deer	LJ	TF	2.82	4.92	-20.12	3.37
White-tailed deer	BZ	TF-I	2.78	3.50	-19.61	3.92
White-tailed deer	BZ	TF-II	2.82	2.59	-10.51	7.02
White-tailed deer	BZ	TF-II	2.80	7.00	-19.22	3.48

^aHuman remains aged and sexed by Theresa Linda Jolly.

^bSexed female.

^cThese specimens derive from the same individual.

^dSex indeterminate.

^eIndicates subadult.

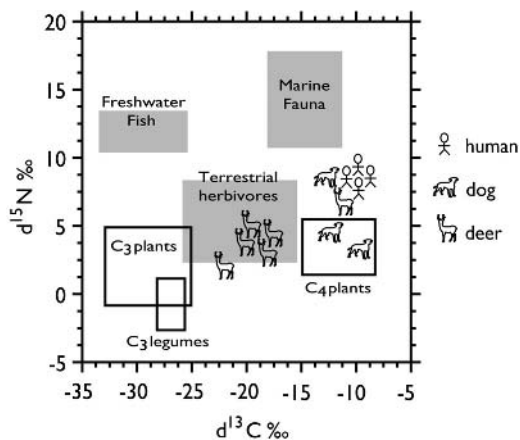


FIGURE 6.5. Stable carbon and nitrogen isotope values for archaeological samples of human, dog, and deer from La Joya and Bezuapan.

for C₄-plant consumers and marine diets. According to the archaeobotanical data, maize was the dominant C₄ plant consumed at La Joya and Bezuapan. Thus, these $\delta^{13}\text{C}$ values indicate that maize formed a significant portion of the diet of these Terminal Formative individuals. The nitrogen values range between 7.42 and 9.35, midway between the ranges for terrestrial herbivores and freshwater fish. The $\delta^{15}\text{N}$ values indicate that these individuals had a faunal diet consisting mostly of terrestrial herbivores mixed with freshwater aquatic species.

Three dog specimens dating to the Late and Terminal Formative periods yielded $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values. The carbon values range between -9.47 and -12.78 , indicating a diet based largely on maize. Based on similar $\delta^{13}\text{C}$ values for Preclassic dogs from Colha in Belize, White et al. (2001:97, 100) suggest that people may have fed maize to dogs for the purpose of consuming the dogs at feasts. While people may have been fattening up dogs at La Joya and Bezuapan for similar purposes, it is also possible that these dogs scavenged heavily on maize refuse and human fecal matter—a scavenging behavior which would have resulted in elevated $\delta^{13}\text{C}$ values (see also Gerry and Krueger 1997:201). The nitrogen values for the study dogs range between 3.16 and 7.91, indicating a focus on terrestrial herbivores. A close comparison with White et al.'s (2001:97) dogs from Colha reveals higher $\delta^{15}\text{N}$ values for the La Joya and Bezuapan dogs. This difference probably reflects an elevated contribution of freshwater and marine fauna to the diet of the study dogs. Indeed, the diet of these dogs is similar to the diet of the three human individuals from La Joya and

Bezuapan discussed above. This similarity may be a result of a combination of the scavenging and hunting behavior of the dogs. In addition to scavenging from human-generated midden piles, dogs probably also hunted small prey close to the residential base in gardens and agricultural fields. Dogs may have garden-hunted in much the same way as humans.

With one exception, the white-tailed deer samples all yielded comparable $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values, falling within the expected parameters for terrestrial herbivores. The La Joya and Bezuapan deer isotope data are broadly comparable to data from Colha (White et al. 2001:98) and other Mayan sites (Emery 1997; Gerry and Krueger 1997; Tykot et al. 1996; White et al. 1993). The exception to this pattern at Bezuapan is represented by a specimen that dates to the second Terminal Formative occupation—this specimen yielded a $\delta^{13}\text{C}$ value of -10.51 and a $\delta^{15}\text{N}$ value of 7.02 . While the nitrogen value is well within the range expected for terrestrial herbivores, the carbon value is much higher, within the range expected for maize consumers. These results suggest that this particular deer may have regularly fed in maize fields. Some have suggested that elevated $\delta^{13}\text{C}$ values in deer may indicate the presence of semi-domesticated deer, which people fed as tame animals (Dillon 1988; Pohl 1990; Gerry and Krueger 1997). It is difficult to know whether this particular deer represents a semi-domesticate. It is possible that this deer simply made a habit of eating in the milpa, and that the incorporation of its skeletal remains into the Bezuapan faunal assemblage may have been the result of garden hunting by humans.

DISCUSSION

The stable carbon and nitrogen isotope analysis presented in this chapter has enabled the consideration of dietary consumption patterns of several individuals, both human and animal. The sample of human individuals was small, consisting of one subadult and two adults. While large samples are always preferable, in that they allow us to examine variation within a population, the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for these individuals provide an important starting point for documenting chemical signatures of diet during the Formative period. Though restricted in time to the Terminal Formative period, the results of this analysis indicate that maize played a central role in the human diet during this time, supplemented by terrestrial herbivores and freshwater aquatic species. Maize also appears to have been important to the diet of the three domestic dogs included in the analysis. Indeed, the $\delta^{13}\text{C}$ values are very similar for both dogs and humans in

these samples. This is not really all that surprising, considering that dogs are scavengers by nature and often eat what their humans eat, whether in the form of table scraps or fecal matter. This relationship between the diets of humans and domestic dogs, at least during the Terminal Formative period in this region, suggests the future possibility of using $\delta^{13}\text{C}$ values from dogs as a proxy measure for humans in the absence of human skeletal material. Before such an analytical leap could be made, however, larger samples of humans and dogs would need to be tested to see if this pattern is robust.

The $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for the white-tailed deer specimens fall within expected parameters for terrestrial herbivores. One white-tailed deer specimen, however, yielded a $\delta^{13}\text{C}$ value comparable to that of the human and dog specimens, suggesting a plant diet based largely on maize. While this pattern may indicate that this deer was semi-domesticated (see Dillon 1988; Gerry and Krueger 1997; Pohl 1990), it is more likely that this animal simply fed in maize fields on a regular basis. Maize fields undoubtedly provided easy and convenient forage for deer—and deer loitering in the maize fields would have provided easy and convenient hunting for people.

Reconciling these data with the plant and animal data discussed in the previous chapters is a slippery task. Because the human isotopic data come from only three individuals dating to the Terminal Formative period, understanding temporal variation in diet using these data is impossible. Thus, we cannot correlate the changes identified in the plant and animal assemblages throughout the Formative sequence with the isotopic data. The isotopic data do tell us, however, that even in the face of increased subsistence risk during the Terminal Formative period, people continued to make maize the cornerstone of their diet. The importance of maize and maize production is also supported by evidence of maize intensification identified from the plant data, and of garden hunting identified from the animal data. In the following chapter, I summarize the major trends identified in the plant, animal, and isotopic data and weave these data together to form a larger tapestry of Formative foodways.

FARMING, HUNTING, AND FISHING
IN THE OLMEC WORLD: A MODEL
OF OLMEC SUBSISTENCE ECONOMY

Chapter 7

The relationship between agricultural intensification and the emergence of political complexity has been examined in many different regions of Mesoamerica. These investigations have demonstrated that the timing of these processes varied dramatically with respect to geography, ecology, and culture history. Understanding the relationship between agricultural intensification and political complexity among the Gulf Coastal Olmec has long been hindered by a paucity of subsistence data and an ongoing debate regarding the nature of regional political complexity. The research presented here has addressed this relationship through analyses of archaeobotanical, zooarchaeological, and isotopic data from two Formative sites in the Sierra de los Tuxtlas, approximately 100 km northwest of the large Olmec capitals centered at the sites of San Lorenzo and La Venta. These analyses have revealed much about Formative farming strategies in the Tuxtlas. While it is possible to correlate changes in subsistence economy with changes in regional politics, a thorough examination of regional political economy (e.g., the mobilization of tribute from villages and hamlets to political centers) requires the excavation and analysis of additional Formative sites in the Tuxtlas. In addition, an adequate comparison between the Tuxtlas and the Lowland Olmec awaits the collection and analysis of more subsistence data from sites located in the Olmec heartland.

My goals at the outset of this project involved establishing the types of plants and animals exploited by Formative Tuxtla villagers and the frequency of their exploitation, tracing changes in subsistence from the Early to Terminal Formative periods through integrative analyses of floral and faunal remains, and determining the extent to which Formative Tuxtla villagers relied on wild versus domesticated foodstuffs. Without a doubt, this study has begun to establish an inventory of Formative plant and animal food resources in the Tuxtlas. Moreover, the analyses presented here have sought to trace changes in subsistence strategies throughout the Formative period—unfortunately, small sample sizes for the Middle and

Late Formative periods have limited a clear understanding of subsistence change during these periods, although the Early and Terminal Formative periods are better understood. Formative villagers began to intensify agricultural production sometime between the Early and Terminal Formative periods—more accurately pinpointing this transition requires the excavation and analysis of subsistence data from additional sites spanning the Formative period.

In the sections that follow, I summarize the patterns presented in Chapters 4 through 6 and correlate them with changes in sedentism, regional settlement, storage, ground stone data, and evidence of field ridging. I organize the discussion by period and consider issues of tribute mobilization, volcanic activity, subsistence risk, and agricultural intensification. In so doing, I relate these regional issues to the larger theoretical topics discussed in Chapter 2.

SUMMARY OF PATTERNS

Analyses of the archaeobotanical, zooarchaeological, and isotopic data have offered a means through which to better understand changing subsistence in the Sierra de los Tuxtlas. Patterning in the plant data suggests an intensification of maize production during the Formative period, coupled with an increase in the harvesting of tree fruits. Evidence of garden hunting in the animal data suggests that people became increasingly committed to farming. Changes in faunal patterning during the Terminal Formative period suggest that this was a time of increased subsistence risk, probably associated with volcanic eruptions. Moreover, isotopic data from human skeletal remains indicate that maize formed the dietary basis by the Terminal Formative. These data paint a picture of a changing subsistence economy throughout almost two millennia. Given such an expansive period, the timing of many of these subsistence-based changes is difficult to pinpoint and easily glossed over. This section synthesizes the subsistence data by period in an attempt to better understand the timing of maize intensification, the nature of subsistence risk, and the potential of tribute mobilization. In addition, I incorporate evidence of settlement, material culture, and agricultural facilities (e.g., field ridging).

The Early Formative Period (1400–1000 BC)

Tuxtla residents were relatively mobile during the Early Formative, moving seasonally or annually (Arnold 2000; McCormack 2002). It was not

until the end of this period that people began to establish more permanent settlements. They grew maize using a shifting cultivation strategy, and their plots were probably scattered across the landscape in areas adjacent to prime foraging areas. In addition to planting maize, Early Formative people harvested wild and domesticated tree fruits, hunted a wide variety of terrestrial animals, and fished a great deal. Although the diet was highly diversified, the plant data indicate that maize was an important plant resource during the Early Formative. In addition to being mobile forager-farmers, early Early Formative people were also relatively egalitarian (Arnold 2000; McCormack 2002). As population levels increased and people began to settle down toward the end of the Early Formative period, they retained an ethos of egalitarianism. A volcanic eruption coincided with this shift toward sedentism and may have influenced the decision to settle down—ashfall following the eruption would have blanketed parts of the region, thereby limiting land available for foraging and farming (McCormack 2002; Santley et al. 1997). Moreover, the abundance and distribution of wild plants and animals would have been negatively impacted.

The Middle Formative Period (1000–400 BC)

Once people were fully sedentary, they began altering their subsistence practices and material culture. Although the subsistence data from Middle Formative contexts are few, some trends are nevertheless apparent. Tuxtla residents began to shift their faunal procurement strategies away from fish and other aquatic fauna and toward terrestrial mammals that prefer disturbed habitats. They continued to cultivate maize and to harvest avocados and coyol palm fruits. Ceramic assemblages became more diverse, indicating the development of a wider range of cooking and serving practices (McCormack 2002). The manufacture and use of ground stone tools was also more specialized than during the Early Formative period, suggesting an increased focus on maize grinding, and by extension, maize production and consumption (McCormack 2002).

Although the faunal data suggest an increase in garden hunting, which may be indicative of an increased commitment to maize-based farming, and the ground stone data suggest an increase in maize production, the plant data from this period are simply too sparse to speak to changing farming strategies. Nevertheless, it appears that maize-based farming may have become a more important subsistence strategy than it was during the Early Formative period. Villages and hamlets formed the basis of the

Middle Formative settlement system in the Tuxtlas, with no known political centers established at this time (Santley et al. 1997). Individual households appear to have been independent and self-sufficient, and society at large continued to be relatively egalitarian (McCormack 2002).

The Late Formative Period (400 BC–AD 100)

The Late Formative period heralded the emergence of social ranking in the Tuxtlas. Regional population increased, and the first regional center was established at the site of Chuniapan de Abajo (Santley et al. 1997). Despite these changes in settlement and social ranking, the level of sociopolitical complexity in the Tuxtlas was not nearly as pronounced as among the lowland Olmec (McCormack 2002; Santley and Arnold 1996). Archaeobotanical evidence points to a continued focus on maize and tree fruits. Beans may have become a more important crop during this time as well. Standardized counts of maize did not change significantly at either La Joya or Bezuapan, indicating that maize consumption may have been relatively stable through time. Changes in maize kernel-to-cupule ratios, however, indicate an increase in maize processing relative to consumption at La Joya. The increase in maize processing at La Joya probably reflects a combination of settling down and focusing on maize cultivation in fields located near the residence. These changes in maize processing may also reflect an intensification of production. The faunal data suggest a continued focus on terrestrial disturbance animals indicative of garden hunting. A decrease in faunal species diversity also suggests that farming had become a less risky subsistence strategy. It is interesting that agricultural intensification corresponds to an increase in regional sociopolitical complexity. I will pursue this topic further in the discussion below.

The Terminal Formative Period (AD 100–300)

Regional population declined dramatically during the Terminal Formative period, and a new regional center was established at the site of Chuniapan de Arriba (Santley et al. 1997). Volcanic activity toward the end of the Late Formative and during the Terminal Formative likely influenced people's decisions to leave the region (Santley et al. 1997). Those who stayed in the Tuxtlas continued to grow maize. Stable carbon and nitrogen isotopic data indicate that maize formed the mainstay of the Terminal Formative diet. People further intensified maize production by con-

structing ridged fields, and they increasingly harvested and consumed tree fruits like avocados, sapotes, and coyols.

Hunting strategies, however, changed drastically from earlier periods. At La Joya, people diversified their faunal procurement by exploiting a wider range of habitats than they had during Middle and Late Formative times. At Bezuapan, people continued to focus on garden hunting but became less selective about the animals they were willing to eat. Although hunting strategies differed between these two communities, they nevertheless point to a decrease in species selectivity. I argue that this shift is indicative of increasing subsistence risk. Despite increasing risk, Terminal Formative people continued to focus their subsistence economy around farming.

It has been suggested that regional elites centered at Chuniapan de Arriba and Tres Zapotes may have commanded agricultural tribute from villages like La Joya and Bezuapan (McCormack 2002; Pool 1997). Increases in storage volume at both La Joya and Bezuapan point to the accumulation of agricultural surplus, which may have been used to help support regional leaders (Arnold 2000; Pool 1997). Indeed, residents of Bezuapan dealt with this period of risk by diversifying their garden-hunting strategy, which would have allowed them to maximize their faunal returns while continuing to devote labor to their agricultural fields. Whether or not tribute demands from regional elites could have precipitated this period of risk is another issue. Did regional elites have sufficient power that their tribute demands alone could have stressed village-level subsistence? Given the scale of regional political complexity during the Terminal Formative period and the nature of chiefly power, it seems unlikely that excessive tribute demands could have been enforced. If people were dissatisfied with elite demands, they simply could have left the region, as many others chose to do at the end of the Late Formative period.

It is more likely that volcanic eruptions at the end of the Late Formative and the middle of the Terminal Formative influenced people's decisions to alter their subsistence strategies. The short-term effects of volcanic eruptions and ashfall on maize production would have been devastating. It is possible that, despite increasing subsistence risk precipitated by volcanic activity, Tuxtla villagers were still encouraged to provide tribute to regional elites. Determining the flow of tribute from villages to centers, however, requires the excavation and analysis of additional data.

DISCUSSION: THEORIZING THE TUXTLAS

Understanding the theoretical implications of the patterns presented above requires a reconsideration of the topics discussed at the beginning of the book. Chapter 2 examined a variety of theories and ideas regarding the origins and intensification of agriculture and the emergence of political complexity (e.g., chiefdoms and states), including population pressure and competitive feasting models, as well as voluntaristic and coercive theories. When examined in light of these different models, the data and interpretations I have presented paint a picture that integrates aspects from multiple theoretical perspectives.

The Population Pressure Model

The population pressure model asserts that increasing regional population would have led to resource scarcity (Binford 1968; Cohen 1977; Redding 1988; see also Watson 1995). When faced with this type of subsistence risk, people could have either opted to leave the area for greener pastures or they could have chosen to intensify agriculture to get more food per unit of land. However, if the regional populace was circumscribed by other populations (social circumscription) or by a more hostile environment (environmental circumscription), then it would have been difficult to simply pick up and leave.

Based on regional settlement data, population pressure does not seem to have been an issue in the Formative Tuxtlas (Santley et al. 1997). Nevertheless, the concept of environmental circumscription may be useful for understanding regional developments during the Terminal Formative period. Repeated volcanic eruptions in the Tuxtlas would have placed new limits on agricultural potential by rendering areas unarable in the short term. In addition, populations of wild plants and animals within the zones of eruption and ashfall would have been impacted, reducing the abundance of local food resources. When faced with these circumstances, many people did opt to leave, but many others stayed behind. Those people that remained in the Tuxtlas dealt with this new uncertainty by intensifying maize production and diversifying their hunting strategies.

By placing a new limit on habitable and arable land and wild food resources, volcanic activity in the Tuxtlas would have significantly shrunk (at least temporarily) the regional carrying capacity during the Terminal Formative. It is possible that the size of the Late Formative population was simply too large to be supported by the altered Terminal Formative

environment, leading to regional depopulation. An alternative explanation, however, is that volcanic activity during the Terminal Formative created an environmental landscape that many people considered too economically risky, so they left. Whether or not the carrying capacity actually shrank enough to place pressure on resources is not really the issue—what is important is that when Terminal Formative people were faced with regional environmental catastrophe, they weighed their options, examined the risks, and then chose either to stay or leave. Those that stayed changed their subsistence strategies as a means of coping with the risks of making a living in the region.

The Competitive Feasting Model

Hayden (1992, 1995) has proposed that agriculture may have developed in the context of competitive feasting, specifically in ecologically rich places or areas of plenty. In striving for status, aspiring elites would have hosted social events at which they served and displayed domesticates to potential followers. Hayden (1992, 1995) and others (Blake et al. 1992; Clark 1991; Clark and Blake 1994) argue that domesticates like maize were not initially incorporated into the diet as staple foods. Rather, aspiring elites introduced maize to the general populace as a special, exotic food imbued with prestige. Thus, burgeoning social inequality would have been marked by the small-scale cultivation of domesticates—domesticates that would not become important staples in the diet until much later. Moreover, domesticates would be expected to be recovered archaeologically in either public feasting contexts or higher-status households, but not throughout the community.

Given the rich and diverse ecology of the Sierra de los Tuxtlas, this region can be considered an area of plenty (*sensu* Hayden 1992, 1995). Similarities to the competitive feasting model, however, end there. In the Tuxtlas, maize was a significant plant food resource by the Early Formative period, nearly a millennium before the emergence of social inequality in the region. Although Early and Middle Formative Tuxtla farmers may not have been intensively cultivating maize, it was nevertheless the most important plant food during this time. In terms of the other expectations of the competitive feasting model, it is difficult to assess whether maize was restricted to certain spatial contexts during the Early and Middle Formative periods based on the data from La Joya. Archaeobotanical samples were not numerous enough to permit a spatial analysis. However, McCormack (2002) has demonstrated a lack of internal status

differentiation at the site during the Early and Middle Formative periods through spatial analyses of other artifactual materials. Thus, a preferential distribution of maize remains in special high-status areas of the site is unlikely, given that there do not appear to be any high-status areas during these time periods.

Voluntaristic and Coercive Theories

Voluntaristic theories explain the emergence of political complexity as being the result of a societal need for economic managers. Leaders arise and are voluntarily given power by the populace because they are needed to manage increasingly complex economies—for example, the intensification of agriculture (Carneiro 1970; Service 1962). In the Tuxtlas, people were farming successfully for 1,000 years before the establishment of a political hierarchy. Although the timing of maize intensification appears to coincide with the emergence of chiefdoms during the Late Formative, the level of intensification was not great. The only evidence of intensification at this time is elevated levels of maize processing in residential contexts, which may reflect the cultivation of more infields—this change in farming strategies does not mean people were investing significantly more time and labor than they had during previous periods. While farmers may have been cropping their plots for a slightly longer period of time before fallowing,¹ it is unlikely that they would have needed special managers to direct them in farming tasks they had already been conducting for a millennium.

Rather than explaining the emergence of political complexity in terms of peaceful managerial necessity, coercive theories highlight the idea of compelling power—that is, the need for aspiring elites to control basic resources in order to compel people to submit to their demands and authority. While this model may apply in areas of scarcity in which potential leaders could co-opt the means of basic subsistence production (e.g., irrigation systems) (see Wittfogel 1957), it is less explanatory for areas of plenty like the Tuxtlas. Irrigation would have been largely unnecessary in the Tuxtlas, where substantial annual precipitation allows for year-round cropping. Indeed, with the exception of the Terminal Formative, resources necessary for basic subsistence economy in the Tuxtlas during the Formative period would have been plentiful—and aspiring elites would have had little control over the volcanic activity that plagued the region during the Terminal Formative.

Another aspect of compelling power is the enforcement of compliance through warfare and conquest (Carneiro 1970, 1981). Carneiro's warfare argument rests on the assumption of population pressure in areas of scarcity. Similar to the model presented above, population pressure, combined with limited agricultural land, would have led to environmental circumscription. Increasing population pressure both inside and circumscribing the region would have made it difficult for people to disperse when resources became scarce. Thus, the combination of these factors would have set the stage for armed conflicts over land ownership, and the victors of these conflicts would have become the ruling elite.

Despite the apparent evidence for environmental circumscription in the Tuxtlas during the Terminal Formative period, evidence of warfare is lacking. Although resources (e.g., agricultural land and forage) in the Tuxtlas would have become scarcer during the Terminal Formative period, similar resources in lowland areas neighboring the Tuxtlas would have been relatively unaffected by the volcanic activity in the Tuxtlas. That population levels declined during this time indicate that it was possible for people to disperse into areas outside this volcanic region.

THE FORMATIVE TUXTLAS IN THEORETICAL PERSPECTIVE

The above discussion highlights some important points regarding the timing and nature of sedentism, agricultural intensification, and the emergence of political complexity in Sierra de los Tuxtlas. Early Formative residents of the Tuxtlas were farming maize before they settled into permanent villages. Indeed, maize appears to have been the most important plant food resource at this time. People were relatively egalitarian during the Early and Middle Formative periods, and maize was a staple crop throughout this time. Nevertheless, people continued to rely on hunting and fishing as major subsistence activities. Given their mobility and the exploitation of a variety of different faunal habitats, people probably practiced an extensive slash-and-burn farming strategy.

After settling into permanent villages, it would be another 600 years before the beginnings of institutionalized social inequality. The emergence of chiefdoms (suggested by a three-tiered site hierarchy during the Late Formative) appears to coincide with the beginnings of maize intensification. Sometime during the Late Formative, people began to cultivate fields located closer to the residence. The pattern is clear at Bezuapan,

though less apparent at La Joya because of small sample sizes during that period. Evidence of field ridging at both sites indicates that Tuxtla residents continued to intensify maize production well into the Terminal Formative period.

That the emergence of complexity and agricultural intensification appear to have co-occurred suggests that elites may have had a role in spurring the intensification of maize production. The new elite were probably not managerial leaders, and would not have directly affected maize production by instructing farmers when and how to plant and harvest. The new elite probably did not force the general populace into submission through the control of basic subsistence resources or aggressive conflict. Rather, it was probably leaders' ability to mobilize surplus for their consumption and for sponsoring community labor projects that prompted farmers' decisions to continue intensifying maize production. Indeed, elite power in the Tuxtlas was probably not great enough to extend beyond the collection of tribute, and thus farmers likely remained autonomous in terms of their decisions regarding day-to-day subsistence economy.

Although the specifics of the competitive feasting model discussed above do not fit the Tuxtla data (e.g., in terms of maize as a special prestige food), the general theme of status competition through the hosting of community events may be relevant for understanding the Late Formative period (see also Clark and Blake 1994). By amassing an agricultural surplus, an individual or lineage would have had the means through which to host food-related events. Those individuals or lineages that were consistently able to generate agricultural surpluses would have been in a position to continue hosting and sponsoring public events in the community (see also Scarry 1993b). By continually hosting such events, they would have earned status in their communities and created uneven relationships in which they became privileged. It may well have been this cycle that planted the seeds of social inequality during the Late Formative period.

When volcanic activity renewed at the end of the Late Formative and continued through the Terminal Formative, much of the populace opted to leave the Tuxtlas (Santley et al. 1997). Those that remained continued to intensify maize production. The cultivation of more infields at La Joya during the Terminal Formative probably reflects both a new limitation on available farmland caused by repeated ashfall in the region and the efforts of regional elites to mobilize tribute. As discussed above, it seems as though environmental circumscription may have played a role in maize intensification during the Terminal Formative period. While some may

criticize this explanation as environmentally deterministic, environmentally catastrophic events like volcanic eruptions cannot be ignored by archaeologists—nor could they have been ignored by Terminal Formative Tuxtla villagers trying to make a living.

Though Tuxtla villagers were clearly affected by volcanic eruptions, the subsistence data indicate that the residents of La Joya and Bezuapan responded to the threat of food shortages very differently. La Joya villagers continued to cultivate maize and harvest tree fruits, but they re-allocated time and labor toward hunting and fishing in a wide variety of habitats. In contrast, Bezuapan villagers focused most of their time and energy on maize production and procured most of their animal protein through diversified garden hunting. Volcanic eruption and ashfall would have certainly affected the sustainability of different subsistence practices and the choices people made with respect to subsistence. To understand why the residents of La Joya and Bezuapan responded so differently to environmental catastrophe, however, we must consider larger regional political developments. Volcanic activity, regional depopulation, and the relocation of the regional political center all point to increasing regional political fragmentation at the close of the Late Formative period (see also Pool 2000; Santley et al. 1997; Stark 1997). Elites would have been unable to maintain political control throughout the region, and some villages may have been more loosely integrated into the political hierarchy than others. Within this context of political fragmentation, the subsistence data suggest that the residents of Bezuapan may have been less politically autonomous than the residents of La Joya. When faced with the environmental degradation following volcanic activity, the villagers of Bezuapan focused almost exclusively on farming, whereas the villagers of La Joya combined hunting and fishing with farming.² It is possible that Bezuapan villagers focused their efforts on farming despite the effects of ashfall because they had to fulfill tribute obligations—obligations that, for whatever reason, the residents of La Joya did not fulfill (see Chapters 4 and 5).

In sum, the data suggest that maize was an important staple crop in the Tuxtlas by the time people settled into permanent villages. The emergence of political complexity in the region followed the shift to sedentism by approximately 600 years. The initial intensification of maize production coincided with the rise of regional leaders and was likely a product of tribute mobilization encouraged by these aspiring elites. After repeated volcanic activity in the region following the emergence of political complexity, the continued intensification of maize production appears to have been a product of increasing environmental circumscription.

CONCLUSION

In examining the timing and nature of agricultural intensification and the emergence of political complexity in the Sierra de los Tuxtlas, this research has made significant theoretical and methodological contributions toward understanding this process. It appears that the periods of maize intensification during the Late and Terminal Formative periods are best explained by both social and environmental factors. While many explanations for the relationship between agriculture and political complexity have given primacy to the social over the environmental or vice-versa, I argue that both social and environmental interpretations need to be considered together. In Chapter 2, I defined agriculture as a social process, in that the transition to agriculture has nearly always involved major changes in material culture and social organization. Although I stand behind this definition, agriculture is nevertheless as firmly rooted in the environment as social inequality is tied to social process. When we take people out of the environment, we can never fully understand subsistence economy. Likewise, if we ignore social process, we can never hope to understand political transformation. It is only through an even treatment of the environmental and the social that we will ever understand political economy.

The methodological contribution of this work lies in the integration of multiple lines of subsistence evidence. Each line of evidence—floral, faunal, and isotopic—adds an additional layer to the complex story told here. As in a novel, each type of archaeological data represents a character, and the development of each character adds fullness and understanding to the story being told. Without the floral data, I would not have been able to identify the shift to infield production, nor, as a result, agricultural intensification. Without the faunal data, I would not have been able to isolate a period of subsistence risk during the Terminal Formative. Without the isotopic data, I would not have been able to show that Terminal Formative people continued to make maize the cornerstone of their diet despite increasing subsistence risk during this time. Together, these lines of subsistence evidence have allowed me to understand the relationship between agricultural intensification and the emergence of political complexity as a dual social-environmental process. Hopefully this brings us that much closer toward understanding an Olmec political economy.

NOTES

2. AGRICULTURE AND POLITICAL COMPLEXITY IN THEORETICAL PERSPECTIVE

1. The term “social” is defined in this context as of or pertaining to society. This definition is necessarily broad and meant to subsume human constructs such as politics, economy, and ideology. Thus, the shift to agriculture can be seen as a social phenomenon in that it is accompanied by a major shift in politics, economy, and ideology.

2. Winterhalder (1990) and Winterhalder and Goland (1997) also point to a change in sharing strategies with the shift from foraging to farming (see above). They differ from Hayden (1992, 1995), however, in that they explain this change in sharing as a shift in adaptive strategies that *accompanies*, not *causes*, the shift to farming.

3. An alternative for explaining the origins of agriculture in terms of political economy deals more specifically with the generation of agricultural tribute for supporting the elite and will be discussed in the following section.

4. The difference between extensive and intensive cultivation strategies will be discussed more in depth in Chapter 3, in terms of Killion’s (1987) infield/outfield model.

5. Small-scale irrigation, as it is used here, refers to irrigation that does not require organization beyond the household level. Thus, “small-scale” refers to shallow-well irrigation techniques like pot irrigation (Flannery et al. 1967), as opposed to extensive hydraulic canal systems.

3. POLITICS AND FARMING IN THE OLMEC WORLD

1. While it is possible to plant four annual maize crops, not all would be planted on the same plot. At most, two crops would be planted on a single plot.

2. As these data have not yet been published, it is difficult to assess whether the beans identified at San Lorenzo represent wild, domesticated, or semi-domesticated specimens.

3. Rust and Leyden (1994:198–199) argue that this small popcorn variant (characterized by multiple small ears, small kernels, and kernels with thin endo-

sperms) was better adapted to wet growing conditions than modern maize variants, and further suggest that it served as the dominant maize cultigen of the tropical lowlands.

4. Farming in the region occurs at elevations below this zone.

5. The archaeological sites considered here are located in this southern portion of the Tuxtlas.

6. What Santley and colleagues refer to as the early Early Classic period (AD 100–300) has been classified elsewhere as the Terminal Formative period. Thus, I discuss this period of time (AD 100–300) as the Terminal Formative period.

7. Unfortunately, we know little about the importance of cultigens other than maize due to the limited amount of archaeobotanical research in the region, in addition to a lack of published archaeobotanical reports.

4. FARMING, GARDENING, AND TREE MANAGEMENT

1. N_2 -fixation has a similar, though reduced, effect on maize yields if maize and beans are cropped in succession.

5. HUNTING, FISHING, AND TRAPPING

1. See Chapter 4 for a discussion of recovery methods.

2. Animal bones from flotation samples were identified to taxonomic class in order to assess the effects of class-based size bias in recovery methods (see above).

3. Small sample sizes from Middle Formative contexts prohibit adequate comparisons with this period.

4. An overhunting of larger species might also lead to a decrease in the size of these animals.

5. Large game may have either been depleted through overhunting close to home or because of the negative effects of volcanic eruption and ashfall. The slower reproductive rates of larger mammals, in comparison with those of smaller mammals, would have meant a slower rebound for larger mammals.

7. FARMING, HUNTING, AND FISHING IN THE OLMEC WORLD

1. The evolution of the bean from perennial climbing forms to annual bush forms would have allowed for field cropping, and the benefit of N_2 -fixation provided by intercropping with beans may have allowed for a slightly longer cropping period.

2. Residents of Bezuapan certainly hunted, but their hunting occurred largely within the context of farming activities (garden hunting) and thus reflects their overwhelming focus on farming.

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